Global Perspectives on Health Geography

Yemi Adewoyin *Editor*

Health and Medical Geography in Africa

Methods, Applications and Development Linkages

Springer

Global Perspectives on Health Geography

Series Editor
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Global Perspectives on Health Geography showcases cutting-edge health geography research that addresses pressing, contemporary aspects of the health-place interface. The bi-directional influence between health and place has been acknowledged for centuries, and understanding traditional and contemporary aspects of this connection is at the core of the discipline of health geography. Health geographers, for example, have: shown the complex ways in which places influence and directly impact our health; documented how and why we seek specific spaces to improve our wellbeing; and revealed how policies and practices across multiple scales affect health care delivery and receipt.

The series publishes a comprehensive portfolio of monographs and edited volumes that document the latest research in this important discipline. Proposals are accepted across a broad and ever-developing swath of topics as diverse as the discipline of health geography itself, including transnational health mobilities, experiential accounts of health and wellbeing, global-local health policies and practices, mHealth, environmental health (in)equity, theoretical approaches, and emerging spatial technologies as they relate to health and health services. Volumes in this series draw forth new methods, ways of thinking, and approaches to examining spatial and place-based aspects of health and health care across scales. They also weave together connections between health geography and other health and social science disciplines, and in doing so highlight the importance of spatial thinking.

Dr. Valorie Crooks (Simon Fraser University, crooks@sfu.ca) is the Series Editor of Global Perspectives on Health Geography. An author/editor questionnaire and book proposal form can be obtained from Publishing Editor Zachary Romano (zachary.romano@springer.com).

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Chapter 1
Health, Diseases and Development: An Introduction to Health and Medical Geography in Africa

Yemi Adewoyin

1.1 Introduction

Africa's development is tied, in many ways, to the health and well-being of its population. Through its direct and indirect impacts on labour productivity, population health and well-being matters for economic development at the individual and household levels and at the level of the national economy. The importance of good health and well-being for development runs, explicitly or impliedly, through the fabrics of the global and regional development agenda of the United Nations and the African Union. The Sustainable Development Goals (SDGs) and Agenda 2063 are a case in point. The effects of a loss in man-hour due to ill-health resonate beyond the bottom line of both the affected employee and their employer. They have consequences for the gross domestic product of the country involved. A study by the World Health Organization (WHO) regional office for Africa, for instance, estimated the productivity loss arising from morbidity and premature mortality from a wide range of diseases and health conditions in Africa at US$ 2.4 trillion in 2015. The study showed the total losses as 629,603,271 disability-adjusted life years (DALYs) with communicable diseases, maternal and perinatal mortality and nutritional conditions accounting for 59.1% of the losses while 30.7% and 10.2% were attributable to noncommunicable diseases and injuries, respectively (WHO, 2019).

Tackling diseases and promoting health and well-being are therefore prerequisites for accelerating social and economic development in Africa. Yet, by virtue of its geography – climate, vegetation and other physical environmental factors – the continent presents a landscape that supports the thriving of diseases and predisposes

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its population to sickness and ill-health. Prothero (1981: 298) captures this succinctly when he observes that Africa presents conditions where 'diseases flourish and health is impaired … (the disease promoting) conditions are to be found not only in the rural areas where the majority of the population are at risk but also in the urban areas into which increasing numbers of people are being drawn'. Further, geography impacts the capacity to provide healthcare facilities for the population's health-seeking. As argued by Adewoyin & Odimegwu (2022), with Africa's estimated 1.34 billion people and a landmass of 30.4 million square kilometres (slightly larger than the United States, Europe and China combined), providing services such as healthcare to a dispersed population of 43 per square kilometre would be more expensive than when the population is clustered. 'The provision is made more difficult with a terrain that is as low as 155 m below sea level at Assal, Djibouti; as high as 5.9 km at Kilimanjaro, Tanzania and; interspersed with forests, mangroves, mountainous ranges and other physical geographical barriers' (Adewoyin & Odimegwu, 2022: 25).

Beyond the effects of the physical environmental factors in the aetiology and transmission of diseases and in healthcare services provision and utilisation, the geography of the social environment also impacts health and well-being. The interplay of political, social and economic systems and the inherent cultural diversity in African societies provide that different locales within the continent are associated with different attributes and features. Places differ. When attention shifts away from the physical environmental factors in tackling diseases and promoting health and well-being, the geographical variation in the characteristics of places becomes a fulcrum around which issues on the social determinants of health are dissected. It follows, therefore, that with the myriad of place characteristics, finding a one-size fits-all solution to health issues on the continent is an endeavour in futility. Despite these challenges, health outcomes in Africa have not been stagnant. They have improved considerably. According to a United Nation's report (UN, 2022), life expectancy at birth for both sexes was 60.3 years in the year 2020, from 37.5 years in 1950; infant mortality declined from 176.3 per 1000 live births in 1950 to 49 in 2021; and mortality for women aged 15–50 had reduced by half from 309 per 1000 females in that cohort in 1950. But more needs to be done.

To gain more strides and address development issues in Africa through the health pathway requires a multidisciplinary approach that recognises the centrality of geography to health and disease, as shown in the foregoing and as encapsulated in the subdiscipline of health and medical geography. Traditionally known as medical geography (May, 1950), the subdiscipline was preoccupied with the spatial variation in the causes, distribution and prevention of diseases; disease mapping; and with issues of healthcare planning and health services provision (Mayer, 1982; Meade & Emch, 2010; Rosenberg & Wilson, 2005). Its focus was on the geographical patterns and environmental determinants of disease and the spatial distribution of health services, including access and utilisation issues related to the facilities (Meade & Earickson, 2000). With its preoccupation with disease, and the primacy of space in explaining disease pattern, medical geography seemingly precluded its practitioners from focusing on the absence of disease. A 'new' health geography influenced by the WHO's definition of health as being a state of physical, mental and social well-being, and not merely the absence of disease (WHO, 1946), thus emerged. The new health geography recognised that the totality of an individual's health and well-being, not just disease and ill-health, could be explained through a geographical lens.

It also recognised that conditions in an individual's social environment matter for that individual's health. The conditions include those in which people are born, grow, live and work and their age, income, gender, culture and education, as well as the generality of the social, economic and political systems under which the individual subsists (WHO, 2008; Oppong & Harold, 2010; Giesbrecht, 2018). The WHO refers to the conditions as the social determinants of health (WHO, 2008). Central to health geography and also a distinguishing factor between research in the subdiscipline and in other disciplines using the social determinants of health model, like public health, epidemiology and social work, is the geographic concept of place. A place could be a specific location, a fixed set of coordinates or political jurisdiction and a convergence of various elements and facets that dictate people's overall experiences (Crooks et al., 2018). A place is a location charged with meanings (Gatrell & Elliot, 2015). It is an operational living construct which matters as opposed to being a passive container in which things are simply recorded (Kearns & Moon, 2002). Places possess distinguishing characteristics that influence occurrences in them and shape the inhabitants' health outcomes.

While some practitioners prefer the original name, medical geography, despite the criticism that it suggested a biomedical orientation to understanding health issues and focused largely, and unduly, on disease ecology, some others prefer health geography to reflect their interest in health and wellness and its social determinants. The preference for some is the all-encompassing label 'health and medical geography' as it allows for a greater flexibility in addressing all sorts of questions from disease ecology to healthcare planning and the social determinants of health. It provides an enlarged scope covering the whole gamut of health and wellness and the absence of same. In all the cases, there is a recognition that the subdiscipline has evolved in content, scope and methodology and that there is a fluidity in its practitioners' approach that suggests that there are no strict boundaries. It is the researcher's personal choice to determine how far traditional or contemporary they are willing to tilt in addressing their subject of interest. Whichever label one adopts, I define the subdiscipline as that branch of human geography that focuses on the interrelationships between the environment, both physical and sociocultural, and the totality of human health and wellness in providing explanations for variations in health and disease outcomes in and among places.

1.2 Rationale for the Book

In spite of the several practical development implications of the explanations provided in studies in health and medical geography on the continent of Africa, there is no pan-African compendium from which policymakers and researchers can draw. Until Makanga's (2021) efforts in 'Practicing Health Geography – The African Context', there were no books that were devoted to wholly documenting research and case studies on African health and medical geography. There are also no discipline-focused journals on the subject in Africa. This is in spite of the fact that majority of the more than 1200 universities and research institutions on the continent provide undergraduate and postgraduate programmes in geography. This stems from, among other reasons, the relative newness of the subdiscipline in African research institutions; the general lack of understanding of the discipline of geography, which to the uninitiated is about names of places, rivers and mountains (Ikporukpo, 2002); and identity issues by researchers in allied disciplines who incorporate environmental factors in their adoption of the social determinants of health model.

Published works on health and medical geography in Africa have featured mainly as journal articles and conference papers. At best, a few African case studies appeared as chapters in health and medical geography books authored by non-Africans (McGlashan (1972) and Hazen and Anthamatten (2011), for instance). In other instances, the disease landscape in Africa is used as a discussion point in the books (Brown et al., 2010; Meade et al., 1988). Before Makanga (2021), earlier attempts to document African health and medical geography, albeit very few, were generalist books on health and disease in the tropics and developing countries. Two notable examples of books in this category are *Health and Disease in Tropical Africa* (Akhtar, 1987) and *The Health of Nations: Medicine, Disease and Development in the Third World* (Iyun et al., 1995). The major shortcoming of these books, in the context of African health and medical geography, is their lack of adequate attention to African and Africanist scholars' narratives on issues of health and diseases on the continent. This drawback further makes a linkage between health and development on the continent less apparent, even to policymakers who rely mostly on foreign texts and institutions to chart policy directions.

Aside Iyun et al. (1995), other books that attempt a linkage between health and development in Africa are either non-geographic (Kalipeni et al's *Public Health, Disease and Development in Africa*, 2019) or not wholly African in content (Kerr & Luginaah's *Geographies of Health and Development*, 2015). The present endeavour seeks to fill these gaps by presenting a book on health and medical geography in Africa, written from an African perspective, with wholly African case studies and with the recognition of the health-development nexus for better health and development outcomes in Africa. The health-development linkage and the attention given to the evolution and current state of the subdiscipline, as well as its theoretical and methodological underpinnings, differentiate this endeavour from other previously published books on or related to health and medical geography in Africa. The book is designed to be both an academic material and a guide for practitioners and development policymakers. The content, therefore, is intended for a varied audience that includes students, teachers, researchers, practitioners, development policymakers and the general public.

1.3 Structure of the Book

The book, *Health and Medical Geography in Africa – Methods, Applications and Development Linkages*, comprises 23 chapters. The first chapter illuminates the connection between health and development in Africa and argues for enhanced recognition of the centrality of geography to health. It also provides a general overview of the subdiscipline of health and medical geography and presents a general outline of the book. The remaining 22 chapters are structured into 5 parts. The first part addresses the nature of the subdiscipline and its perspectives and methods. The second part is devoted to the interrelationships among environment, health and disease. The third part of the book presents case studies on health and well-being while the fourth part focused on location and health behaviour. Issues in health inequalities and healthcare planning are presented in the fifth part.

1.3.1 Nature, Perspectives and Methods

Yemi Adewoyin discusses the prevailing paradigms in the practice of health and medical geography in Africa in Chap. 2. The discussion focuses on the philosophical perspectives of empiricism, positivism, structuralism and humanism that were found to be more prevalent in the literature. He further describes the nature of questions in the works of health and medical geography practitioners using the frameworks of disease mapping, disease ecology, healthcare planning and the socioeconomic determinants of health. He also highlights the methodological approaches employed in the literature on health and medical geography in Africa and draws on the works of Stanley Okafor and the late Folasade Iyun, recognised as pioneer indigenous practitioners, and other local examples and case studies to enrich the discussion. In Chap. 3, Yusuf M. Adamu, Ishaq Aliyu Abdulkarim, Fa'iza Isa Sheshe and Oyekanmi Isaac Babatimehin trace the historical origins, with emphasis on the works of pioneers in medical geography in Nigeria, notably Professors Folasade Iyun, Stanley Okafor and Dora Shehu, and describe the current state of teaching and research in medical geography in Nigeria. They conclude that there is a steady growth in the subdiscipline and that despite some challenges, medical geographers are increasingly becoming important and their contributions are being recognised in the health research arena in Nigeria.

In Chap. 4, Olusesan Ayodeji Makinde discusses traditional and nontraditional data sources useful in research in African health and medical geography. He contends that there is an ever increasing need to improve the assessment of the health of people and their social determinants beyond the population and institution-based data sources that have traditionally been the source of data for measuring national development plans including the Sustainable Development Goals. He highlights the advantages of integrating nontraditional data sources into the data generation processes by national statistical offices in Africa. The nontraditional data sources he identifies include citizen science/crowdsourced data, search engine queries, social media data, mobile phone records and data from sensors. These nontraditional data sources, he concludes, can redefine the measurement of health and development interventions in Africa. Using their work on the prevention of Buruli ulcer in the southern part of Benin Republic as an example, Alexandra Boccarossa and Sébastien Fleuret expound on a novel methodology for disease prevention in Chap. 5. The methodology involved a combination of GPS-based geolocalisation with a case-control study, the combination of data collection methods derived from approaches developed in social and human sciences with microbiological analysis and a longitudinal follow-up of cases oriented towards direct observation.

1.3.2 Environment, Health and Disease

Using geo-additive Bayesian survival models, the spatial analysis of antiretroviral therapy (ART) among adults in Zimbabwe HIV was the preoccupation of Zvifadzo Matsena Zingoni, Tobias F. Chirwa, Jim Todd and Eustasius Musenge in Chap. 6. They aimed to describe the spatial heterogeneity of antiretroviral therapy (ART) attrition and identify the hot spots for ART attrition and its correlates for strengthening ART retention in Zimbabwe. Their analysis of secondary data shows that the risk of attrition increases with an increase in the number of years on ART and that individuals enrolled at a provincial/referral or district/mission facilities and tuberculosis-infected patients had an increased risk of ART attrition. They conclude by suggesting ways of minimising ART attrition and optimising the benefits of the HIV ‘treat-all’ strategy.

In Chap. 7, Mary Kalerwa Muyonga, Janet Wanjiku Keru and Miriam Kaloki Wandia present evidence on mobility and disease diffusion in East Africa with a focus on HIV/AIDS, Ebola and the coronavirus (Covid-19). Their review of literature reveals that the diffusion patterns of the three diseases varied. For Ebola, cross-border mobility was responsible for its spread from the epicentre in Uganda to Rwanda while HIV prevalence was clustered around the Lake Victoria for all the countries that bordered it. Covid-19 was found to diffuse hierarchically from the capital cities to the periphery, with the pattern mirroring internal migration flow. Esther Nako, Lochner Marais and Michelle Engelbrecht also focused on migration and health in Chap. 8. Their concern, however, was on the management and prevention of HIV infection in migrant miners in Lesotho and South Africa using the capability approach. Using material from interviews with 50 miners from Lesotho who work in South African mines, they investigate social and environmental factors that make it difficult for the migrants to avoid contracting HIV or to access antiretroviral therapy. Some of these include the availability of commercial sex, self-isolation, poor housing, migration-imposed constraint on some freedoms, work-based problems, the negative attitudes of health staff, administrative red tape and poor service delivery.

A geographical analysis of malaria in Nigeria is presented in Chap. 9 by Ishaq Aliyu Abdulkarim, Ismaila Ibrahim Yakudima, Jamila Garba Abdullahi and Yusuf M. Adamu. The chapter examines malaria incidence in Nigeria across space and time using data from the Malaria Atlas Project database. Their findings show a spatial variation within states and geopolitical regions in the country with the highest incidence of 437 cases per 1000 people in the northwest region and the lowest incidence of 321 per 1000 population in the southwest region. The geographical distribution and temporal patterns were displayed using choropleth maps and graphs. On their part, Collins Otieno Asweto and Patrick Ogola Onyango discuss antimicrobial resistance in a changing climatic context as an emerging health threat in Africa in Chap. 10. The chapter is predicated on the argument that climate change exacerbates the development of resistance to therapeutic agents for the treatment of microbial infections and that a high prevalence of antimicrobial resistance (AMR) significantly decreases the ability to treat infections effectively, thereby increasing complications, hospitalisations and unnecessary costs to healthcare.

1.3.3 Health and Well-Being

The issue of climate change and health is amplified in Chap. 11 by Yemi Adewoyin, Henry N. Ugwu, Juliana C. Onuh, Lekan M. Sanni, Aina T. Adeboyejo and Clifford O. Odimegwu. They present a general overview of what climate change is and how its direct and indirect effects are associated with disease prevalence and population health outcomes. In discussing these associations, examples of climate-related diseases and other health conditions highlighted in the literature are presented. Essentially, the chapter is structured and written to serve as a basic text in educating a varied audience on the health effects of climate change. Justine N. Mbukwa, Tukae Mbegalo and Francis Levira present an analysis of the spatial distribution of gender-based violence in Tanzania in Chap. 12. They argue that the issue has not been well documented geographically in Tanzania. They are able to show, through their analyses, that sexual violence was more prevalent in the lake and central zones of Tanzania and that wealth index, marital status, partner's education, drinking habit and occupation were the main drivers. Similarly, Loveline Kongla Nsahlai, Kouankem Constantine and Petnga Nyamen Simon Pierre focused on gender-based violence, particularly against rural and poor urban women (RPUW) in Cameroon in Chap. 13. They note that health outcomes of GBV against RPUW were influenced by location and cultural differences.

In Chap. 14, Ademola Luqman Adeagbo discusses the issue of menstrual hygiene management (MGM) in the context of water sanitation and hygiene (WASH) policies. On the premises that MGM practices have implications for students' learning ability, school readiness, attendance, concentration and effective participation in school activities and that an effective MGM will depend on the effectiveness of the prevailing water, sanitation and hygiene (WASH) policies, he gives a general overview of WASH policies and strategies in Nigeria and attempts to describe how the policies reflect in MGM practices in schools in Nigeria. The author draws his case studies from two subnational units in Nigeria to account for the diversity of geographical and sociocultural characteristics in the country. Love Ugonna Umesi examines the nexus between development and early childhood mortality in Nigeria in Chap. 15. She explores the spatial inequity in under-five mortality in Nigeria through the lens of key social development factors. Her findings show that under-five deaths were higher in the northeast and northwest regions of Nigeria while the most regional progress made over the period her study covered were in the southeast and south-south.

1.3.4 Location and Health Behaviour

In Chap. 16, Olukemi F. Awelewa examines the issue of identity and health-seeking among street children in Ibadan, Nigeria. Her study adopted a mixed method of data collection using open-ended questionnaire, interview and direct observation. Of the 209 participants in her study, 64.6% were male and 35.9% were natives while others were internal migrants. Almost half of the sample had no formal education, while 91.9% did not have access to healthcare. Majority (62.7%) were living in inner city and other areas that lacked basic sanitary amenities and more than half were using illicit substances. She further discusses the implications for health and national development. Tsholofelo L. Molale and Peter N. Eze's contribution in Chap. 17 focuses on the biochemical functions and potential human health implications of soil ingestion, geophagy. They note that geophagy is most prevalent among women and children in sub-Saharan Africa. They argue that biochemical functions of geophagy include absorption of dietary and bacterial toxins related to gastrointestinal disturbances and supplementation of nutrients like iron, zinc and calcium but that it may also be harmful to human health. Their contribution presents a perspective to human nutritional behaviour and associated health implications.

Nutritional behaviour also receives attention in Chap. 18 where Anthony Mwinilanaa Tampah-Naah, Adams Osman and Joseph Nyaaba Akongbangre describe the spatial analysis of breastfeeding practices and childhood morbidity episodes in Ghana using interpretivist and positivist research frameworks. They observe that protective effects of breastfeeding practices against childhood morbidity disappeared in the midst of other risk factors. Their study also shows major hot spot districts for breastfeeding practices. They conclude that the Ministry of Health and Ghana Health Service should scale up sensitisation on breastfeeding to reduce episodes of childhood morbidity in the country. While Chap. 18 focuses on babies' nutrition, Chap. 19 by Rebecca L. Upton discusses issues around infertility and cross-country search for babies through assisted reproductive technology (ART) in what she titled ‘Test-Tube Transnationalism: Fertility Migrants and Reproductive Refugees and the Provision of Care Across Southern Africa’. From the angle that in vitro fertilisation (IVF) and other assisted reproductive technologies (ART) remain inaccessible to many in Southern Africa, and that a growing number of ‘fertility migrants’ have emerged in contexts where fertility and fecundity signify productive status as persons, she narrates her experience with women whose lives have been shaped by the landscape of infertility in Southern Africa.

1.3.5 Health Inequalities and Healthcare Planning

Ifeoma Evan Uzoma discusses issues of location, accessibility and socioeconomic status on the low coverage of child immunisation in Nigeria in Chap. 20. With the background that the major target of the Expanded Programme on Immunisation (EPI) in Nigeria was the reduction of infant, child and maternal mortality, she presents evidence on how the factors have impacted the level of coverage recorded. The chapter also shows rural-urban differentials and subnational regional disparities in the coverage. The geographical coverage of health facilities and approaches to defining health facility catchment areas in sub-Saharan Africa receive the attention of Peter M. Macharia, Julius N. Odhiambo, Eda Mumo, Alex Maina, Emanuele Giorgi and Emelda A. Okiro in Chap. 21. They argue that a catchment area forms the basis of estimating reliable population denominator for disease mapping and routine healthcare planning and that approaches used in delineating it have a direct impact on the health of a population. They therefore present the results of a systematic review on the different approaches and discuss their limitations. They conclude that to generate a closer-to-reality catchment area for robust disease mapping and healthcare planning, additional data and innovative approaches balancing between model complexity and routine programmatic use are required.

Ellen Gondwe, Michael G. Chipeta and Lawrence N. Kazembe examine access to health facility and the frequency of antenatal care (ANC) visits in Malawi using Bivariate Copula Regression modelling in Chap. 22. Their results throw up a number of factors affecting access to health facilities and ANC visits in Malawi. They conclude that women with more ANC visits are more likely to have a facility close to their location and suggest that increased access to health facility, through mobile clinics, and initiating ANC early should be an important policy intervention for improved maternal and neonatal health. Euloge Makita-Ikouaya, Christian Wali Wali and Stéphane Ondo Ze analyse the territorial distribution of doctors in Gabon in Chap. 23. Their review of documented evidence shows a spatial distribution highlighting the disparities between different healthcare regions in Gabon at the expense of less urbanised regions of the country. They recommend the application of national standards, as against the WHO standards, for addressing the distribution of doctors.

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Part I
Nature, Perspectives and Methods

Chapter 2
Philosophy, Questions and Methods in Health and Medical Geography in Africa

Yemi Adewoyin

2.1 Introduction

The debates on the nomenclature for the subdiscipline of geography concerned with health issues are yet to abate. The debates have not only challenged the appropriateness of 'medical geography', the name with which the subdiscipline was originally known (May, 1950), but also thrown up a few other names for consideration in its stead. Some of them include geographical epidemiology, the geography of disease, public health geography, post-medical geography, health geography, geographies of health and geography of health and disease (Crooks et al., 2018; Gatrell & Elliot, 2015; Kearns & Collins, 2010; Kearns & Moon, 2002; Mayer, 2010; Rosenberg, 1998). One central argument in the debates, and as implied in the variety of alternative names, is in ensuring that the scope of subjects investigated in the subdiscipline reflects, broadly and adequately, in the name with which the subdiscipline is labelled. In this chapter, as with the title of the edited volume under which it appears, I refer to the subdiscipline as health and medical geography to encapsulate all issues relating to the geography of disease, health, and well-being as Emch et al. (2017), and Brown et al. (2010) before them, had done.

Like with its parent discipline, geography, the subdiscipline of health and medical geography is characterised by a philosophical pluralism that provides alternative, and sometimes complementary, approaches to investigations and narratives within the subdiscipline. Concerns about labelling notwithstanding, the prevailing philosophy, questions and methods in health and medical geography mirror the different paradigms in the broader human geography tradition. See Johnston (1986,

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1991) and Okafor (1989a, 2001) for insights on the latter. Paradigms, according to Kuhn (1970), refer to the totality of beliefs, values and techniques shared by members of an academic discipline in their approaches to providing explanations for the subjects of their research investigations. To Johnston et al. (1994), paradigms connote 'the working assumptions, procedures and findings routinely accepted by a group of scholars, which together define a stable pattern of scientific activity' (p. 432).

Okafor (2001) posits that traditions specify the problems and nature of questions being addressed in a discipline as well as the methods employed in providing acceptable answers to them. He argues that shared traditions are the hallmark and defining characteristics of an academic discipline and that the connection between paradigm and methods is mediated through philosophy as every paradigm has an underlying philosophy. An acceptable answer (Okafor, 2001) constitutes an explanation in geographical research. In the classic, Explanation in Geography (Harvey, 1969), explanation is described as any satisfactory or reasonable answer to a 'why' or 'how' question that geographers ask. Inquiries on 'how such questions might arise, how we might proceed to construct answers, and how we might judge whether or not the answers given are reasonable and satisfactory' (Harvey, 1969: 11) encapsulate the notion of methods in a research endeavour.

In this chapter, I present an overview of the philosophical dimensions in studies on health and medical geography in Africa. The idea is to examine which of the routes to providing explanations in health and medical geographic research in Africa are more prevalent and why that may be so. Using case studies from the African continent, I also examine the nature of questions asked in the studies as well as the methods of investigation employed in providing acceptable answers or explanations to the questions asked. The questions are organised to depict some thematic areas covered in the subdiscipline. The review is representative, rather than exhaustive, and relies essentially on documented evidence from countries adjudged as contributing more to knowledge production in Africa (Paraje et al., 2005; Prothero, 1981; Tijssen, 2007; Uthman & Uthman, 2007).

2.2 Philosophical Approaches

In the literature on health and medical geography across the world, six philosophical approaches are predominant. These are empiricism, positivism, humanism, structuralism, structurationism and poststructuralism (postmodernism). A few other not-so-prevalent approaches include post-humanism, non-representationalism and new materialism (Crooks et al., 2018). While the pluralism of paradigms 'may appear to the uninitiated as a cacophony of fission', the paradigms provide perspectives on the human condition that are seldom captured in other fields (Gould, 1996: 453). The plurality of paradigms 'ensures that human geographers provide knowledge of greater dimensionality' (Okafor, 2001: 2). In the health and medical geography literature with case studies in Africa, only the first four of the six predominant philosophical approaches were observed with different degrees of prominence. I discuss the four approaches in details in the following subsections. As some of the works employed more than a philosophical approach, aspects of the work that fit the description of a particular philosophy, where applicable, are used as examples to buttress the discussion.

During my review, I also found a few works that could be used as examples in structurationism, but for a lack of clear methodological approach to structurationism to aid my classification of such works, I have decided to concentrate only on the four dominant theoretical perspectives in the African literature. Reacting to the methodological issue, and as quoted in Okafor (2001), Sarre et al. (1989: 53) opine that 'our response was to utilise familiar methods of data gathering and analysis but to seek to interpret the data we collected in the light of emerging realist and structurationist views'. For clarity, structurationism presents an alternative perspective to positivism by recognising the interrelationships between structure and agency in providing explanations for health issues. In relation to other perspectives, structurationism is a melting point for structuralism and humanism. As Gatrell and Elliot (2015) put it, structuration acknowledges that structures shape social practices and actions, but that, in turn, such practices and actions can create and recreate social structures. Structuration theory emphasises the ways in which actions and practices interacted with structural constraints to both transform and reproduce social structures (Entrikin & Tepple, 2006).

2.2.1 Empiricism

Empiricism is a philosophical approach that places primacy on the description of events in places. Aitken and Valentine (2006) describe it as a philosophy of science that emphasises empirical observation over theory, which, in other words, suggests that facts (observations) should speak for themselves. Put differently, empiricism is concerned with observations and the description of what was observed without attempting to draw any causal inference. Its aim is not to test a hypothesis, formulate a law or theory or attempt a generalisation based on the observations. Its emphasis is only on fact gathering and the presentation of facts (Okafor, 2001) - a fact that made him (Okafor) liken empiricism to the regional description that characterised traditional regional geography.

Traditional regional geography was preoccupied with gathering and presenting facts on climate, relief, drainage, soil, population distribution, agricultural production and output, industrial activities and other attributes about places. Empiricism may also involve the gathering and presentation of several facts about a single phenomenon. The presentation of such facts concurrently does not imply that the researcher is suggesting causality but that the events may be related in space. Indeed, many of the earliest works on health and medical geography in Africa adopted the empiricist approach (Adesina, 1979; Iyun, 1984a, b, 1987, 1989; Sule, 1981, for instance). Recent studies that somewhat fit into the empiricist framework include those by Kabatereini et al. (2004) on the epidemiology and geography of intestinal schistosomiasis in Uganda, Tenge et al. (2009) on the burden and pattern of cancer in western Kenya, Onyekwelu et al. (2018) on the incidence of infant mortality consequent on gastroenteritis in a part of southeast Nigeria and Deka (2020) on the geographic distribution of tungiasis in sub-Saharan Africa.

After arguing for increased recognition of health and medical geography practitioners in the understanding and resolution of health-related problems in Africa and highlighting some of the earliest practitioners' works, Iyun (1989) illustrated the relevance of health and medical geography from her studies on the spatial variation of the top ten diseases in Ibadan, Nigeria. She presented the geographical expressions of malaria, schistosomiasis, filariasis and ophthalmia neonatorum using choropleth maps. In her words, the aim was 'to provide visual baseline data that could be more convincing than statistical tables to health workers' (Iyun, 1989: 36). Her other works on 'visual baseline data' included those on chickenpox and tuberculosis. Works as these typified the disease mapping/disease geography perspective of the traditional medical geography (Iyun, 1998; May, 1950; Mayer, 2010).

In line with the advances in mapping technologies and the attendant ascendance of geographic information systems (GIS) for map making, the copious presentation of digital maps to show the incidence of gastroenteritis and associated infant mortality in Onyekwelu et al. (2018) was not surprising. Beyond providing a spatiotemporal expression of the cases, they conducted a cluster analysis to show the disease hot spots. The authors however went a step away from empiricism when they sought to establish, seemingly an afterthought, an association between disease incidence and the population's sources of water for domestic use. Kabatereini et al. (2004) similarly used GIS to map the distribution of schistosomiasis infection and to overlay maps on parasitological data and environmental characteristics to show a widespread occurrence of infection and a spatial variation in infection prevalence. Like with Iyun (1989), Deka (2020)'s evidence-based maps on the potential geographic extent of tungiasis in sub-Saharan Africa are to help in guiding policymakers to understand the severity of the disease with a view to formulating appropriate disease control programmes. Tenge et al. (2009) offered no concurrent presentation of facts on ecological conditions that may be associated with the burden and incidence of cancer they studied. They simply presented the facts on the gender of patients and the types of cancer they presented in Western Kenya.

2.2.2 Positivism

The major criticism of the empiricist mode of research is that it is not 'scientific'. By this, critics of the perspective imply that empiricism does not follow the method of science which entails the identification of a problem as a starting point and the establishment of laws as the end point. They accuse empiricism of being long on facts and short on theory and formulation of laws (Okafor, 1998) – an endeavour in the realm of science. The aim of science, according to Braithwaite (1960), 'is to establish general laws covering the behaviour of the empirical events or objects with which the science in question is concerned, and thereby to enable us to connect together with our knowledge of the separately known events, and to make reliable predictions of events as yet unknown' (p. 1). This presupposes that a standard route for gathering facts, seeking an association or a relationship among the facts gathered, providing an explanation on the association or relationship observed and making a generalisable prediction of the observations, must exist before an explanation becomes acceptable. This alternative perspective is positivism. It is also known as the scientific or spatial analysis paradigm (Okafor, 2002).

In positivism, facts are not left to speak for themselves. Rather, the researcher interrogates the facts with a view to identifying patterns and answering questions on why certain events occur or are located where they are. Kitchin (2006) describes positivism as a set of philosophical approaches that seeks to apply scientific principles and methods, drawn from the natural and hard sciences, to social phenomena in order to explain them. This, according to him, involves the objective collection of data through methods of observation that could be replicated and the formulation of theories which could be tested, as against empiricism where observations are presented as fact. 'Such testing would be systematic and rigorous and would seek to develop laws that would explain and predict human behaviour' (p. 20). To avoid subjectivity and emotions in recording observations, quantification is used in positivism, and explanation is based on statistical inference. The paradigm is therefore based on the observable, measurable and generalisable (Gatrell & Elliot, 2015). The process involves problem identification, formulation of hypothesis, data collection, statistical testing of the hypothesis and law formulation or model building.

As Okafor (1998) observes, the quantitative revolution, on which positivism is built, is a post-World War II development in geography partly inspired by the perceived superiority of the generalising approach over the descriptive approach to research. It is, thus, a quest for relevance and it necessitated the redefinition of geography as a spatial science. With this background, one could understand why the first indigenous generation of health and medical geography practitioners in Africa (Prothero, 1981), seeking a solid footing for the subdiscipline and, perhaps, relevance in the scientific medical fields, embraced positivism early in the life of the subdiscipline (Adesina, 1981; Iyun, 1984c; Okafor, 1977, 1979; Uyanga, 1981). Okafor's works investigated spatial efficiency in the location of public facilities rendering secondary healthcare services in a part of Nigeria using linear programming. Adesina employed statistical analysis to describe the distribution of cholera and the characteristics of cholera patients in a Nigerian city. Similarly, Uyanga and Iyun employed multivariate statistics to show the regional correlates of child nutrition and disease pattern, respectively. This foundation, perhaps, informed the orientation of many contemporary practitioners whose works are largely positivist.

Without an attempt at exaggeration, the health and medical geography landscape in Africa is dominated by works enshrined in positivism (Adamu et al., 2003; Ernst et al., 2006; Osei & Duker, 2008; de Wet et al., 2011; Kandala et al., 2011; Govender et al., 2011; Marais et al., 2013; Oguntoke, 2014; Adewoyin, 2015; Adewoyin & Adeboyejo, 2016, 2017; Adeboyejo et al., 2020 for instance). Not only did the studies set out to test some hypotheses or the other, framed in some of the studies as research questions, they employed rigorous statistical techniques to accept or reject the hypotheses. Expectedly, as in the realm of scientific investigations, the studies attempted some forms of generalisation to suggest that where conditions (variables) such as those that were prevalent in the locations of their studies were found elsewhere, the same answers as theirs would be obtained. On the strength of that, the studies concluded with recommendations to the relevant stakeholders. Let us consider a few examples.

In the Democratic Republic of Congo, Kandala et al. (2011) investigated the impact of geographic location on child's nutritional status. They formulated a hypothesis around their argument that 'geographic location is an important modifier of known predictors of malnutrition and is associated with food security and accessibility…' (p. 2). They employed different regression models to test their hypothesis in order to validate their explanation. Marais et al. (2013) were interested in the relationship between housing environments and the mental health of orphans and vulnerable children (OVC) in South Africa. Data on housing conditions (independent variables) and socio-emotional health of the OVC were subjected to bivariate and multivariate statistical analyses to show that living in good quality housing does not necessarily translate to better mental health status. The finding is similar to de Wet et al. (2011)'s on housing quality and health outcomes in poor urban communities in Johannesburg. Such similarities lend credence to the replicability attribute of positivism. They also serve as foundations for building models, like what Adewoyin (2018a) did when he decomposed 30 indicators of residential environmental quality and housing conditions into a few uncorrelated variables to measure population health vulnerability using Cronbach's alpha statistics, factor analysis and hierarchical cluster technique.

2.2.3 *Structuralism*

While empiricists allow the facts to speak for themselves and positivists interrogate the facts to provide explanations based on the outcomes of their statistical analysis of the facts, a third philosophical perspective goes beyond statistics to suggest that the observed outcomes are consequent on the interplay of social, economic and political systems (structures) prevalent in the study area. This perspective believes that positivism is too simplistic by merely relying on some statistical analysis to explain events, when in actual fact, observations (measured quantitatively) are not random but are a product of certain underlying forces within the society. The perspective is referred to as structuralism (Aitken & Valentine, 2006; Gatrell & Elliot, 2015; Okafor, 2001, 2002). It is also known as the political economy perspective.

Okafor (2001) observes that the structural paradigm hinges many of the problems of interest to human geographers on capitalism and that structuralism has strong elements of Marxism. In a similar vein, Gatrell and Elliot (2015) note that structuralism derives, largely, from Marxism and its theories of oppression, domination and class conflict which propose that economic relations and structures underpin all areas of human activity, including health and access to healthcare, and that the economic structures impact social outcomes. Marxism 'is interested in what the world is like and who makes it that way; in what knowledge and feelings people have about their situations and how those perceptions arise from those very situations. It is at root an inquiry into human endeavours of all sorts, with the aim of bringing about more just conditions for human flourishing' Henderson and Sheppard (2006: 57). Health and medical geography practitioners operating under this philosophy provide explanations for diseases and health issues on the premise that the forces of interrelationships among political, economic and social structures are behind the observed facts.

While a positivist would explain the spatial expression of disease as consequent on the population's exposure to disease pathogens based on where they live, a structuralist would be interested in knowing why the people live where they live (income and economic power, social segregation, class and residential segregation, etc.) for them to be so exposed. Many of Okafor's works in health and medical geography are underpinned by structuralism. His concerns with welfarism, social justice and equity are aptly captured by Iyun (1998) in her writing about the three categories of Nigerian geographers who concerned themselves with the analyses of health-related problems. She notes that Okafor leads in the category of those 'who utilise health data, in particular, data on the location and allocation of health resource, to investigate spatial efficiency, equity and social justice' (p. 225).

In one of such works (Okafor, 1982), Okafor examined how aspects of national health programmes impacted the geographical distribution of health facilities in Nigeria. The study found that the distribution of hospitals and doctors was skewed heavily in favour of urban centres. Using data on budgetary allocations to the health sector, he argues that the rural-urban imbalance is attributable to the pattern of health investment between urban and rural areas in previous national development plans. His concerns with the political economy of health facility distribution are also evident in his work on the spatial structure of healthcare provision in Nigeria (Okafor, 1987a, b). On the premise that jurisdictional partitioning, exemplified by the creation of states and local government areas (LGAs), is usually justified as a tool for solving problems of domination, discrimination and inequality in the spatial allocation of social and economic infrastructure in Nigeria, Okafor (1987a, b) assessed the impact of the exercise on the distributional inequality of healthcare facilities in Nigeria. He concludes that although the number of healthcare facilities increased, partitioning did not significantly reduce inequalities in the spatial pattern of healthcare provision; it rather exacerbated the inequality in some cases.

Practitioners who have adopted the structuralist explanations in their works are mainly in Nigeria and South Africa and include Adewoyin (2017a, b, c, 2018b, 2021), Adewoyin et al. (2018), Babatimehin et al. (2011), Groenewald et al. (2010), Marais (2007), Marais and Cloete (2014), Hunter (2007), Osayomi (2020) and Smit et al. (2015). In his works, Adewoyin has looked at issues of urban bias in the provision of healthcare services; socioeconomic segregation within urban centres, typified by residential densities, and their impacts on access to healthcare; political ecology and spatial justice in healthcare provision; treatment policies and health seeking; and the impacts of neoliberal policies, encapsulated in the Nigerian structural adjustment programmes, on disease prevalence. In their work, Marais (2007) highlights the uneven impact of AIDS in a polarised South Africa, showing that the impact is shaped by the highly unequal distribution of power. Social inequalities were also shown to underpin the political economy of sex and AIDS transmission in South Africa (Hunter, 2007). The work by Smit et al. (2015) examined the impacts of economic, social and political forces on the prevalence of noncommunicable diseases in a low-income area in Cape Town, South Africa, while Babatimehin et al. (2011) looked at the spatial distribution of political power, and this reflects on the provision of healthcare facilities.

One social structure that has received very little attention in the structuralist approach to research in health and medical geography, however, is patriarchy. Gatrell and Elliot (2015) capture this succinctly when they argue that there 'are, however, other deep structures embedded in society that are based on conflict and power relations, of which the most obvious is the role played by male power (patriarchy) in structuring women's health' (p. 42). I consider that this structure (patriarchy) has received very little attention for two reasons. Firstly, and as noted by Dixon and Jones (2006), patriarchy is one of the key structures studied by feminist geographers. This implies that the emphasis of works on patriarchy is on 'the systematized exploitation, domination, and subordination – in short, oppression – of women and children through gender relations' (p. 47) and not in relation to women's health in particular. Secondly, until recently, health and well-being, including sexual and reproductive health, as well as the social determinants of health were not considered as themes in the traditional medical geography. Adewoyin appears to be filling the gaps in this area with his works on gender relations and the utilisation of maternal and reproductive healthcare services (Adewoyin et al., 2022a, b, c).

2.2.4 Humanism

Missing in the empiricist, positivist and structuralist approaches to research in health and medical geography is the concern for individual meaning. In other words, in the three perspectives, explanations about health issues are based on the practitioners' observation of what they think the facts are, based on the outcome of quantification and statistical analysis, or in some structural explanation resulting from the interplay of political, economic and social factors with the voice of the individuals in the middle of it all, completely overlooked. Humanism deviates from these approaches and instead focuses on the individuals and their experience of health and illness. Because the meanings of health and illness are constructed out of the interactions with the individuals concerned, and not solely from the perspective of the observer, humanism is also known as social constructionism and social interactionism (Aggleton, 1990). It gives an active role to human agency, human awareness and human creativity (Okafor, 2001). It is about the subjective experience of health and illness by an individual with the researcher's task being to uncover and interpret the meanings of health and illness from the point of view of the individual concerned (Gatrell & Elliot, 2015).

Humanism was one of two major 1970s intellectual movements that grew out of a discontent with positivism (Entrikin & Tepple, 2006). The other being structuralism. Humanists argue that positivists tend to concentrate only on problems that are amenable to scientific analysis but which may be of trivial importance and that their definition of reality excludes phenomena that are internal to the observer, like feelings and intentions (Okafor, 2001). Humanism's major critics are therefore positivists who believe that a subjective, rather than objective (and measurable), route to providing explanations is not scientific and fundamentally flawed. In his observation on the debate, Gould (1996) opines that the 'research of many geographers may be driven by humanistic concerns, yet make genuine claims to scientific procedures and methodologies. The complexity of human life in space and time is only distorted by a too rigid insistence on a division between the humanities and sciences, a division which obscures the simple fact that science is always a human endeavour' (p. 453).

Proponents of humanism are not many in the subdiscipline of health and medical geography in Africa. This may be due, in part, to the dominance of medical anthropologists, medical sociologists and social work researchers, whose disciplinary orientation is largely qualitative rather than quantitative like geography, in the study of health of individuals and groups. It may also be due to the perception in many geography faculties in Africa that geographers who do not align with spatial (statistical) analysis are not to be considered as serious or rigorous. The latter, particularly, reflects in the course contents of research methodologies in the faculties – they are skewed in favour of quantification and statistical analysis with qualitative methodologies that underpin humanistic research, either completely missing or mentioned in passing. Okafor (2002) makes a case for an urgent need to end the romance with the scientific paradigm and encourage research designs that employ in-depth interviews and focus group discussions (humanistic methodologies) because of their capacity to produce richer narratives and provide better explanation and understanding of phenomena.

In a study on women's child delivery outlet preference, Ene et al. (2020) employed the humanistic framework to provide explanation on where women choose to give birth and why. Majority of the women preferred to give birth outside of the health facilities in non-institutional delivery centres because of their perception and experience of the quality of care by health providers, proximity to alternative delivery outlets and cost, among others. The responses were elicited through focus group discussions. Statistics on maternal, neonatal and infant mortality in Nigeria would apparently not have shown the underlying factors responsible for the deaths. Onalu et al. (2020) equally applied the humanistic approach in their study of the barriers to the utilisation of HIV counselling and testing services among youths in Nigeria, just as Upton (2003) used the approach to describe how the role of women as caregivers in communities has been transformed as a result of the HIV/AIDS crisis in Botswana. The work by Monguno and Waziri (2012) that describes the cross-border utilisation of healthcare services across the Nigerian-Cameroon border also fits the description of a humanistic perspective to the study of health and medical geography in Africa.

2.3 Themes in African Health and Medical Geography

As I would show in this section, there is, arguably, no better pointer to illustrate the evolution of the subdiscipline of health and medical geography than the type of questions addressed in the works of its practitioners. While some of the practitioners see a dualism in the nature of the subjects investigated and how they are investigated, others prefer to see the subjects as a reflection of a broader, more encompassing subdiscipline progressing from a somewhat parochial beginning (Crooks et al., 2018; Dorn et al., 2010). In other words, based on the type of subjects being investigated, questions arise as to whether the 'original' medical geography has evolved into a 'new' medical geography, birthed a new subdiscipline of health geography, or is still in its 'traditional' state and coexisting with a 'variant' known as health geography. The debate about content and scope becomes logical when situated in the contexts of how both medical and health geographies, as two distinct disciplines, are defined.

Medical geography is traditionally concerned with issues of spatial variation in the causes, distribution and prevention of diseases (disease mapping and disease ecology), on the one hand, and with issues of healthcare planning and health services provision, on the other hand (Mayer, 1982; Meade & Emch, 2010; Rosenberg & Wilson, 2005). Its focus was on geographical patterns and environmental determinants of disease (and associated mortality) and the spatial distribution of health services (Meade & Earickson, 2000). To underscore the dominance of the disease mapping and disease ecology perspective, which emerged following his works during World War II and the production of the first world atlas of disease, Jacques May, touted as the father of contemporary medical geography, used the term 'geography of disease' as an alternative term for medical geography (May, 1977: 715). The healthcare planning or the spatial analysis of access to healthcare perspective, the second major theme in medical geography, was an addition that came with the scientific paradigm of the late 1960s and early 1970s (Dorn et al., 2010).

By its definition and focus on disease, medical geography seemingly precluded its practitioners from focusing on the absence of disease. Going by the World Health Organization's 1946 definition of health as being a state of physical, mental and social well-being, and not merely the absence of disease, scholars (and proponents of health geography) argued that focusing only on disease and not the totality of health and well-being was a rather narrow approach to providing explanations on how geography is related to and impacts health (Crooks et al., 2018; Kearns, 1993; Rosenberg & Wilson, 2005). The debate about going beyond the biomedical scope of medical geography got a further fillip when the World Health Organization (WHO) recognised that conditions in an individual's social environment matter for that individual's health status and their health outcomes. The conditions include those in which people are born, grow, live, work and age; the presence of social and cultural groups and their interrelationships; the socioeconomic differentiation based on income, gender, culture and education; and the generality of social, economic and political systems prevalent in the individual's society (WHO, 2008; Oppong & Harold, 2010; Giesbrecht, 2018). The totality of these conditions is what the WHO refers to as the social determinants of health, and they constitute the fulcrum around which health geographers' explanation of health and well-being, in places, revolves.

Implicit in the foregoing is the fact that some practitioners prefer to be called medical geographers or health geographers by the nature of questions their research works address. Some, on the other hand, evolve with the trend and questions on health issues without giving as much as a consideration to debates around the name of the subdiscipline. To some, the preference is for an all-encompassing label, health and medical geographer, as it allows for a greater flexibility in addressing all sorts of questions from disease ecology to healthcare planning and the social determinants of health. In illustrating the types of questions in the literature on health and medical geography in Africa, I use the three broad themes – disease mapping and disease ecology, healthcare planning and social determinants of health – for categorisation. Works that fit more into the traditional medical geography theme on disease mapping and disease ecology are so categorised while those that addressed questions on access to healthcare and the provision of healthcare services are captured under the healthcare planning theme. The third category of works addresses health issues from the social determinants of health perspective.

2.3.1 Disease Mapping and Disease Ecology

Pioneer medical geographers in Africa, following their colleagues who specialised in the subdiscipline in North America and Europe, were mostly concerned with disease. Aside the fact that the disease ecology perspective was the more dominant theme at the time, the geographical location of their practice, Africa, was renowned for a wide range of diseases due to the nature of its physical environment (tropical and subtropical climate) and disease-promoting socioeconomic environment (Prothero, 1981). Prothero listed some of the diseases such as malaria, sleeping sickness, schistosomiasis, trachoma and yaws. Questions around the aetiology, transmission, distributional pattern, risk factors, mortality rates and pattern (and other related questions) of these diseases, and many others, were addressed in the works of the pioneers (Adesina, 1979, 1981; Iyun, 1983, 1984a, b, c, 1987; Uyanga, 1981).

Succeeding generations of practitioners have also addressed the disease questions (Abeku et al., 2003; Adamu, 2005; Adeboyejo et al., 2020; Adewoyin & Adeboyejo, 2016; Dzordzormenyoh et al., 2021; Ene et al., 2019; Ernst et al., 2006; Kabatereine et al., 2004; Odimegwu et al., 2020; Osei & Duker, 2008; Tuoane-Nkhasi & van Eeden, 2017) in Ethiopia, Ghana, Kenya, Nigeria and South Africa and elsewhere in Africa. Some of the notable diseases around which questions have been asked are tungiasis, malaria, HIV/AIDS, cholera, typhoid, schistosomiasis, onchocerciasis, tuberculosis, meningitis, measles, gastroenteritis and noncommunicable diseases like asthma, hypertension, diabetes and cancer. Makinde et al. (2021) and Adewoyin et al. (2022a), among several others, further extended the questions to the now-ebbing Covid-19 pandemic. In providing the explanations, the use of maps to illustrate the distribution and risk factors is taken as sine qua non. Disease mapping, on its own, as a route to provide explanation has become less fashionable owing to the decline of the empiricist mode of explanation. It has however gained widespread prominence as a symbiotic bedfellow to disease ecology in the positivist and structuralist perspectives to providing explanations in health and medical geography.

2.3.2 Healthcare Planning

The quantity, quality and arrangement of healthcare resources such as hospitals, doctors, nurses, health workers, hospital beds and ambulances, among others, matter for health and well-being. Their spatial structure and distribution have impacts on the population's access to the resources and their health-seeking behaviour. As geographers have always been interested in accessibility and the distributional patterns of phenomena, the task of extending the two concepts to providing explanations for disease outcomes, mortality, health seeking and utilisation and the provision of healthcare services fell naturally on health and medical geographers. Dorn et al. (2010) referred to these set of geographers as the access-to-healthcare researchers or healthcare geographers because of their concerns with medical services planning. Accessibility is simply the ability to get to a place quickly and cheaply and the availability and affordability of a utility (Ikporukpo, 2002). As conceptualised by Ikporukpo (1987) and Pirie (1979), accessibility is essentially about proximity to a facility and the availability, or otherwise, of constraints and barriers to effective utilisation of the facility. Access is therefore both in terms of average distance travelled to enjoy the facility and costs of utilisation.

Okafor (2007) defines distribution as the extent to which places, individuals or social classes share in the aggregate products of society. Varying distributive factors ensure that some locations get more than a fair share of the products while others have less/fewer than their fair share. The pattern of distribution where some areas have more (or less) than a fair share of whatever is distributed is termed unjust distribution and is usually the basis for questioning the distribution of health facilities and planning for the provision of new ones. Smith (1979) however cautions that an unequal distribution is not necessarily an unjust distribution. To address distributional inequity or an unjust distribution, Runciman (1966), Harvey (1973) and Smith (1979) suggest that three criteria should form the basis for distributing the products of the society. These are merit, contribution to common good and need.

For healthcare planners, need, exemplified by population sizes of locations, and access are the major issues around which their questions revolve.

Works by Okafor (1977, 1979, 1982, 1987a, b, 1989b) and Egunjobi (1977, 1983a, b) pioneered interests in the issues of healthcare planning in Africa by indigenous scholars. While Okafor was more interested in addressing distributional inequity and the locational efficiency of healthcare resources, particularly with respect to population distribution (need), Egunjobi focused on access and utilisation of healthcare resources. Following in the welfare concerns of Okafor, Adewoyin et al. (2018) investigated intra-urban disparity in the distribution of healthcare resources in Nigeria within the contexts of the inverse care hypothesis, where health services are more accessible to people of higher socio-economic status who live in the best parts of a city than to the relatively poor who live in the other parts of the city. Adewoyin (2021) also looked at the rural-urban differential in health services provision and its implications for access to maternal healthcare. Also in Nigeria, Babatimehin et al. (2011) examined the geopolitical distribution of healthcare facilities. Elsewhere on the continent, Kloos (1990), Barker et al. (2002), Alegana et al. (2012), Aoun et al. (2015), Ashiagbor et al. (2020), Ouma et al. (2021) and Moturi et al. (2022) have been concerned with questions in healthcare planning.

2.3.3 Social Determinants of Health

In what appears to be a sharp departure from the traditional medical geography questions of disease and healthcare services provision and utilisation, health geographers focus on the social determinants of health and well-being in places. The questions they ask are as varied as the number of social determinants of health as there are. This development has further brought health geographers closer to practitioners in disciplines with interests in health and their social determinants. These include social epidemiologists, public health scientists, population health scientists, health and spatial demographers, medical sociologists, medical anthropologists, social work researchers and biostatisticians. One major fallout of this development is the propensity for the health geography researchers to unconsciously veer away from 'geography' in their quests to providing explanations for the health and well-being subject of their interests. It is thus common for older generations of geographers and traditional medical geographers to ask at geography conferences and seminars and in the works of postgraduate students, 'where is the geography in your work?'

The geography in works on the social determinants of health is encapsulated in the geographic concept of place. A place is a location charged with meanings (Gatrell & Elliot, 2015). A place could be a specific location, a fixed set of coordinates or a political jurisdiction (Crooks et al., 2018). Place is a more subjective and less intuitive term that speaks specifically to the contextual rather than compositional matters that make up spaces (Macintyre et al., 2002). Places are complex as they are a convergence of various elements and facets that dictate people's overall experiences (Crooks et al., 2018). A place is an operational living construct which matters as opposed to being a passive container in which things are simply recorded (Kearns & Moon, 2002). In the latter sense, space, as opposed to place, underpinned studies in traditional medical geography and is used as the container for describing disease composition and patterns (Dorn & Laws, 1994), whereas places possess distinguishing characteristics such as social and cultural attributes that influence occurrences in them.

Paraphrasing Kearns and Collins (2010), Brown et al. (2010: 3) note that '…medical geography, as then conceived, tended to employ geometric constructions of space that limited our understanding both of the ways in which ill-health and disease (and for that matter good health) were experienced and lived and what role 'place' played in this regard'. The centrality of place in health geography follows from its relationship with health. Places, including the social and cultural processes that make them unique, where people are born, grow, live, work and age influence people's health and well-being and how they access/utilise healthcare. Crooks et al. (2018: 3) summarise the centrality of place aptly; 'it is health geographers' intellectual engagement with place in all its facets that sets this subdiscipline apart from other social-science and health disciplines that are informed by social models of health and social-determinants frameworks'.

Works that utilised the social determinants of health model in the African health and medical geography literature are many, and they constitute the dominant perspective. They are mostly prevalent in Eastern and Southern Africa. In South Africa particularly, the number seems to have stifled the growth of the traditional medical geography themes of disease ecology and healthcare planning. The latter reflects in Marais and Mehlomakhulu (2016)'s paper 'Seriously ill? Diagnosing the state of medical geography in South Africa'. Conversely, Nigerian scholars are mostly inclined towards the traditional medical geography themes with both the disease mapping/disease ecology and healthcare planning perspectives commanding a large number of adherents. In Nigeria, the social determinants perspective is popular among specialists in other health-related disciplines who do not consider themselves health geographers. Works by Adewoyin (2017d), Ajaero et al. (2020), Odimegwu & Adewoyin (2020a, b), Adewoyin and Odimegwu (2022), Adewoyin, Odimegwu and Bassey et al. (2022) on migration, ethnicity, culture, intimate partner violence and gender as social determinants of urban health and reproductive health behaviour and services utilisation are some exceptions. Considering the small number of institutions providing training in health and medical geography in South Africa (Marais & Mehlomakhulu, 2016), the volume of work on the social determinants of health in the country may also have come from other health specialists that accentuated the role of place in their studies.

2.4 Methods of Investigation

Following in the social science tradition of its mother discipline, works in health and medical geography are a blend of quantitative, qualitative and mixed methods research in Africa as elsewhere. As such, I will not dwell much on issues of methodology. As I described in the section on philosophy in this chapter, quantitative research methods are mostly employed in studies that adopt the positivist route to explanation. Structuralist works present a blend of both quantitative and qualitative methods with more emphasis on quantification for establishing association among variables while the underlying explanations for the observations are provided using qualitative methods. Humanistic research is largely qualitative in nature. The preponderance of works rooted in positivism and adopting the social determinants of health model of investigation has ensured that the health and geography landscape in Africa is overly quantitative. As I noted earlier, the perception that works without some elements of statistics are not substantially rigorous, and the need to align with the core scientific methodology in allied health professions like epidemiology and biostatistics may be largely responsible for the practice. There is therefore the need to encourage African researchers to embrace qualitative methodology in their approach to health issues because of its capacity to generate deeper explanations and narratives beyond what statistics can capture or explain (Cloke et al., 1991; Johnston, 1991; Okafor, 1989a, 2001, 2002).

Another plausible explanation for the overwhelming number of quantitative studies would be the nature of data employed by health and medical geography researchers. Major traditional data sources for health research are through field surveys (questionnaire administration, focus group discussion, in-depth interview, field observation, etc.) and secondary data (hospital records, periodic survey reports and surveillance systems and other documentary sources). Some examples from the works I have already cited in this chapter are Govender et al. (2011) and Dzordzormenyoh et al. (2021) – questionnaire administration; Upton (2003) and Monguno and Waziri (2012) – in-depth interview; Ene et al. (2020) and Onalu et al. (2020) – focus group discussion; Groenewald et al. (2010) and Adeboyejo et al. (2012) – hospital records; and Collinson et al. (2007) and Marais and Cloete – periodic surveys and surveillance systems.

Data from secondary sources are typically processed as quantitative data and therefore leave the users with little option than to apply statistical analysis to make sense of the numbers. Secondary data and data from questionnaire administration, which oftentimes end up being coded for statistical analysis, constitute the most widely employed data types among practitioners in Africa. Among the lot, health geographers with the social determinants of health orientation utilise more of secondary while field survey is predominant among traditional medical geographers. Nontraditional sources of data based on the Internet of Things and digital devices and platforms are barely emerging (Makinde et al., 2022). The use of geospatial technologies for map making, spatial analysis and building models is also widespread (Ernst et al., 2006; Osayomi, 2020; Osei & Duker, 2008; Ouma et al., 2021).

Analogue maps are no longer in vogue, and where they exist, they only serve as a data source for analysis in a geographic information systems (GIS) environment through the process of digitisation.

2.5 Conclusion

The subdiscipline of health and medical geography is evolving in Africa. The large body of work by its practitioners reflects the prevailing pluralism of philosophical, thematic and methodological perspectives within the human geography tradition the subdiscipline aligns with. There is geographical thematic orientation that shows that ‘traditional’ medical geography, with its focus on space, disease and the planning of healthcare services, is still widespread in the works of scholars in Nigeria where most of the subdiscipline’s indigenous pioneers practised. Elsewhere on the continent, particularly in South Africa, the perspective focusing on place and the social determinants of health, which its adherents prefer to call health geography, is more widely embraced. Novel and more encompassing as the perspective is that it offers a blurry distinction, found in the geographical concept of ‘place’, between works by geographers and other practitioners interested in health issues like epidemiologists and biostatisticians. Like with the works of these other professionals, the health and medical geography landscape in Africa is largely positivist, with significant emphasis on quantification and statistical inferences. This calls for a philosophical and methodological reappraisal of our route to explanation considering the capacity of alternative routes, particularly humanism and qualitative methodologies, to generate deeper explanations and narratives beyond what statistics can capture or explain.

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Chapter 3
Medical Geography in Nigeria: History, Debates and State of the Discipline

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3.1 Introduction

'What has geography got to do with disease?' Most medical geographers in Nigeria have been asked this question especially when they meet physicians and other health professionals in the process of data collection and interviews or even at conferences. Most often, medical geographers are quick to respond in a simplistic way that health professional can connect: 'we study the seasonal variations of disease, looking at how seasons influence diseases like asthma and other respiratory tract infections…' At times, we also explain that we study the distribution and utilization of health services. This is often understood by them. This short response attracts the attention of physicians, yet in most cases that is where the conversation ends. In addition, medical geographers are not given a chance to explain how location of health services influences their utilization or otherwise nor to explain how ecology and environment influence nutrition or diseases associated with it. This is in spite of the great potentials for collaborative research.

Interestingly, physicians were the ones who promoted the idea of medical geography and developed its foundations. Thus, the importance of geography/environment in the study of both disease and health cannot be overemphasized. The seminal work of Barrett (2000), on the historical origins of medical geography, has shown that the idea that today translates as medical geography started as far back as the

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fourth century BC with the work of Hippocrates known as *On Airs, Waters and Places.* To strengthen the point, Barrett (2000: x) argues that

> Indeed, the record confirms that it was geographically minded physicians who asked geographical questions that laid the origins and almost exclusively developed medical geography.

Over the centuries, physicians have continued to contribute in developing the geographical paradigm of disease. The works of physicians like Friedrich Hoffman (1705), James Lind (1768), Dehorne (1782), Halle (1787) and Ludwig Finke (1792–1795) in the eighteenth century, as explained by Barrett (2000), were the key period when medical geography was formally conceptualized and the term adopted. In the nineteenth century, efforts by physicians to understand the relationship between disease and geography continued. They include contributions such as Friedrich Schnurrer's attempt at a geographical nosology (classification of diseases) who published the first map of the geographical distribution of disease globally in 1827, where he identified points where major epidemic and endemic diseases occurred. They also include the study by Joseph Virey, a naturalist and anthropologist who studied medicine from a natural historical perspective; the study of medical topography by Hannen (1830); and sustained interests of Moritz Hasper (1831) and Jean-Pierre Bonnafont (1839) in linking disease and geography/environment (Barrett, 2000). Despite the rise of microbiology and putting microbes in the equation of disease, the link between disease and place has continued to attract the attention of physicians. The work of Dr. John Snow who used maps in the study of cholera in Soho District in London (1855) led to the linkage of cholera and contaminated water source. Up to the 1950s, Jacques May, another physician, who is considered as the father of medical geography in the United States and who helped to systematize medical geography in the 1950s, consolidates their contributions to a sub-discipline that will end up in another discipline other than medicine. May's works include *Medical Geography: Its Methods and Objectives* and *The Ecology of Human Disease*.

From the 1960s to 1980s, trained geographers began to be interested in studying disease and health from a geographical standpoint. Early contributors such as Prothero, Hunter, McGlashan, Barrett, Learmonth, Pyle, Mayer, Philips, Shoshin, Kearns, Stock, Earickson, Akhtar, Armstrong, Meade and Hirsch, for example, have provided the foundation of what we term modern medical geography in this chapter. Their debates and contributions have been instrumental to all that we study today.

3.2 Debates on the Definition of Medical and Health Geography

Geographers generally study so many things on the Earth's surface making it very difficult to define geography based on what geographers do, because the interests and focus of the discipline keep changing (Livingstone, 1992). Thus, the lack of unity of what geographers do has trickled into its sub-disciplines, including medical geography, as argued by Barrett (1986:2). As with most, if not all sub-disciplines, the concept and definition given depend to a large measure on the concept and definition held of the parent discipline. This relationship between discipline and sub-discipline places a considerable burden on medical geographers because the contemporary conceptualization of geography is more divided than it has ever been.

From the early inception of modern medical geography, there are debates about its nature and scope, as well as the right name for the sub-discipline. May (1970) opines that the sub-discipline should be labeled the geography of disease or epidemiologic geography. The names describe his research interest in disease distribution and the environmental factors influencing them. Scholars like Barrett (1986) are comfortable with the umbrella term of medical geography and even go ahead and argue in its favour. For instance, Barrett justifies that the sub-discipline should be called medical geography owing to the historical roots as outlined in the previous section of this chapter. In addition, geographers investigate the environmental factors that affect disease, rather than examining health as a physical, mental, social and economic status of people. That is why in defining medical geography, you have many definitions just like the mother discipline.

Some geographers are more comfortable with the term health geography or geographies of health (Kearns & Moon, 2002; Kearns, 1993). Geographers like Mayer (2010) are of the opinion that the use of the term medical geography is misleading because according to him, medical has to do with diagnosis, treatment and prevention of diseases and medical geography is not concerned with the first two, even though it may be concerned with prevention. Meade and Emch (2010:2) further explained why health geography is receiving support from some practitioners:

> Health geography has become a popular term as the social dimension of health has become the central concern in economically advanced countries. The need for 'health promotion' and investment in 'healthy cities' and for understanding of the experience of the disabled, elderly, and otherwise vulnerable individuals has become obvious as our population has become older, more obese, more sedentary, more drug-addicted, and more promiscuous. Health geographers usually consider medical geography as too concerned with disease etiology; with accessibility to treatment; and with models that can be used to generalize, predict, and intervene—in short, with "medicine."

The debate continues and individual practitioner may decide which term to use without necessarily negating the other term. Let us now scan some few attempts at the definition of medical geography in order to understand its changing nature and scope. For Jacques May, medical geography is largely based on disease ecology, as it is concerned with the distribution of diseases on the Earth's surface and the environmental factors that contribute to disease distribution. However, his disease ecology model identified both pathogens and geogens, which provide a framework for understanding the relationships between microbes and geographical, biological and social factors. Geographers like Hunter (1974) see it as a framework of using geographical concepts and techniques in studying and understanding human health-related problems. In the 1980s, Barrett (1986) defined it as the analysis of the human-environment relationship of disease, nutrition and medical care systems in order to elucidate its interrelationships in space. He further explained the nature of the sub-discipline as consisting of geographical relationships in three traditions, namely, disease, nutrition and medical (health) care. Earickson (2009:1) supported this assertion in his entry in the *International Encyclopedia of Human Geography*, when discussing about the nature of medical geography:

> Medical geography uses the concepts and paradigms of the discipline of geography to investigate human–environmental relationships of disease, nutrition, and medical care systems, of which maps and geographic information science (GIScience) are arguably most prominent today.

It can therefore be safely argued that medical geography is built on three pillars, namely, disease ecology, nutrition and healthcare. The first two pillars have received more attention while nutrition has been largely neglected by researchers. The debate continues and medical geographers from both camps continue to research and publish on disease ecology and healthcare and to some extent nutrition under different titles. What is important is that geographers are interested and are contributing to the understanding of human health and disease. Geographers in Nigeria are largely tilted towards the use of the term medical geography than health geography, but their works, as will be shown, consist of mainly the two pillars, and most recently, interest is shown in nutrition aspects.

Although in some cases, medical geography and geography of health are interchangeably used (Kearns & Collins, 2010), the question of what geographers are really studying and what they wish to call it, is still important to the extent that some see the two titles as distinctive. Whether we see this discipline as medical geography or health geography, we cannot ignore the fact that it is concerned with diseases, nutrition and healthcare, and it is becoming an increasingly popular area of study and an important tool contributing to our understanding of human health. Medical geography has been taught since the 1960s in the United States, led by scholars such as Hunter (1974) who taught in Michigan University between the 1960s and 1990s, and works done by his students including Meade (1986); Meade et al. (1998), Emch (1995, 1998), Emch and Carrel (2011), Emch et al. (2007, 2017) represent a generation of scholars who taught and researched in medical and health geography. Today medical/health geography is being taught in many universities across the world, including Nigeria. In the next section, we present a historical journey on the development of the medical geography sub-discipline in Nigeria.

3.3 Growth of Medical Geography Scholarship in Nigeria

The medical geography sub-discipline may have started in Nigeria through research conducted during the colonial period leading up to independence of the Federal Republic of Nigeria in 1960. However, the teaching of medical geography did not start until the 1970s at the University of Ibadan (Iyun, 1998), before increasing popularity in other parts of Nigeria. Despite the dearth of information, we will attempt to classify the growth and development of medical geography in Nigerian Universities into four phases that cover periods where works with geographical attributes were carried out on disease and/or health in Nigeria by non-geographers and those conducted by non-Nigerian geographers who have made major contributions in the area through five decades. We describe each of these phases sequentially, highlighting the salient features of medical geography studies.

3.3.1 Pre-1970: The Phase of Pace Setting

This period, also known as the 'Period of Traces of Medical Geography' (Iyun, 1998), was pioneered by non-geographers, which seems a common practice in the initial phase of development of the sub-discipline (Barrett, 2000). In the colonial period, as expounded by Iyun (1998), the relationship between environmental factors – inherently geographical – and the spread of certain diseases had been identified following the commissioning of epidemiological surveys by the colonial government, to investigate certain diseases such as trypanosomiasis, commonly known as sleeping sickness that had plagued the country. Research conducted by Thomas Nash, an entomologist, showed that sleeping sickness affected persons who used stream water believed to be infected by *Glossina palpalis*, the vector causing trypanosomiasis. Despite the presence of this vector across Nigeria, trypanosomiasis was more common in north of Nigeria than south, even though both regions were exposed to the disease-causing vectors (Nash, 1944). There were also works by scientists on malaria in Nigeria in the 1950s. From 1950s to 1960s, there were intervention projects by the World Health Organization on malaria in different parts of the country. In the northwestern part, for instance, there were projects in Kankia (Katsina Province) and Birnin Kebbi (Sokoto Province). A study by a malariologist in the Medical Department of the Northern Region in Nigeria attempted a comparative epidemiology of malaria in representative communities of southwestern and northwestern Nigeria where the climates of the two areas contrasted with a view to understanding their influence on the seasonal densities and infections of the local vectors, *Anopheles gambiae* and *A. funestus*. The study concluded that malaria occurs in holoendemic proportions in both areas (Archibald, 1956). A study like this uses the regional geography tradition to show how regional variations can affect health.

R. Mansell Prothero, a geographer working on human migrations and circulation in Northern Nigeria, by accident, became one of the pioneer geographers to study malaria in Africa, when he was commissioned by the World Health Organization (WHO) in 1968, to work on malaria in Africa (Prothero, 1961, 1962, 1963, 1965). Hitherto, Prothero was a research fellow of the West African Institute of Social and Economic Research, investigating land and people in the northern parts of Sokoto Province in Northern Nigeria in the period 1957–1962. Following his research with WHO, Prothero would publish several studies on the nexus between population movements and malaria from the experimental projects he conducted for WHO (Prothero, 1977, 2001, 2002).

Other pioneer scholars include Bradley, who has worked on onchocerciasis, also known as river blindness, a disease caused by infection with parasitic worm, which sucks the blood of its victims and can lead to blindness. Bradley worked in an interdisciplinary public health project in Northern Nigeria in a collaborative work between the Department of Community Health of Ahmadu Bello University Zaria and the University of Liverpool School of Tropical Medicine (Prothero, 1981). There were also some works on nutrition, as reported by Uyanga (1981), where mention was made of early works on nutrition in Nigeria, though by non-geographers, such as Nicol who studied the nutritional status and requirements of rural Nigerians in the 1950s (1952, 1956, 1959) and Dema (1959, 1963, 1964). These works and Uyanga's works would have set a strong foundation for the nutrition tradition in Nigerian medical geography. Unfortunately, this interest was not sustained.

There were works also by Robert Stock who was in Kano as a volunteer teacher in the 1970s. The cholera outbreak in 1972 changed his life. He came to know about the emerging discipline of medical geography in Dr. John Hunter's course and was fascinated to learn that one could make some geographic sense out of cholera epidemics. He wrote a thesis on the diffusion of cholera, which was subsequently published as a monograph titled *Cholera in Africa*. Later, he also conducted studies on healthcare in the Kano region especially about illness and health-seeking behaviour. He was an assistant lecturer in the Department of Geography at Bayero University Kano (BUK) in the 1970s. His works as a geographer on distance and the utilization of health facilities in rural Nigeria were among the earlier works in health geography in Nigeria. The study found that the rate of distance decay in utilization levels varies according to the type of facility, socio-demographic variables and illness. Hausa people's perceptions about sickness and about specific illnesses are reflected in the varying incidence of health facility utilization in the treatment of particular illnesses and distance decay gradients of varying steepness.

3.3.2 1970s–1980s: Pioneering Nigerian Medical Geography

This phase started in the 1970s when the teaching of medical geography started at the University of Ibadan (Iyun, 1989). The phase is dominated by Nigerian geographers who were interested in studying health from a geographical perspective. They were S.I. Okafor, B.F. Iyun, T.O. Egunjobi, H.O. Adesina, R.A.O Sule and J. Uyanga. Although most of them partly studied outside Nigeria, S.I. Okafor was trained at the University of Ibadan. This pioneering group, in a way, attracted the interests of Nigerian geographers in medical geography. Their doctoral works, listed below, were the early seeds that would germinate and give birth to the teaching and research on disease/health by geographers in Nigeria:

(i) *Spatial Efficiency of General Hospitals in Afenmai, Bendel State, Nigeria, University of Ibadan* (Okafor, 1977)
(ii) *Implication of Health Resources for Regional planning: The Example of Oyo Health Zone in Oyo State, Nigeria. University of Nottingham* (Egunjobi, 1977)
(iii) *Spatial Analysis of Health Care Delivery in Ibadan City.* University of Ghana, Legon (Iyun, 1978).
(iv) *Diffusion Process in Nigeria. The Geographical Analysis of the Spread of Cholera within and around Ibadan*, from January 1971 to August 1974. University of Bristol (Adesina, 1979)
(v) *Spatial Patterns of Urban Mental Health in Calabar (Cross River State) Nigeria* (Sule, 1981)
(vi) *Geographical Correlates of Child Nutrition in South-Eastern Nigeria. Flinders University of South Australia, Australia* (Uyanga, 1981)

Prothero (1981) was impressed with the work of this pioneer group because, as at that time, they dominated the medical geography research in Africa and he saw the promise in Nigerian geographers who he described as having academic rigor because geography flourished in the country. In order to support this promise and encourage more geographers to pay attention to this promising area, at the 23rd annual conference of the Nigerian Geographical Association (NGA), in 1980, Professor H.J. Ajaegbu, then the president of the Nigerian Geographical Association, presented a speech titled *Orientations for Nigerian Geography in the 1980s: the need for medical geographical studies*. The speech was deliberately intended to promote this area that would contribute something new from the traditional contributions of Nigerian geographers. In his speech, he made a case for geographers to be interested in the health problems facing Nigeria by using their skills to understand disease and ill-health using their expertise understanding of the environment (Ajaegbu, 1980). That speech is a recognition of medical geography by the highest body of Nigerian geographers, and at the end of his speech, Ajaegbu prayed that his speech had inspired the participants to venture into medical geography with a view to giving their contributions to national development. Although his speech 'legalised' the sub-discipline, only the pioneer group continued to build this new area in Nigerian geography.

Among this pioneering group, three are most prominent when it comes to teaching and promoting medical geography, namely, S.I. Okafor, the late B.F. Iyun and Dora J. Shehu. Of these, Iyun and Shehu are associated with medical geography because they have identified themselves as medical geographers. Okafor continues to teach and supervise students on health geography but with a rather different perspective, the radical approach. Okafor's works are varied but largely concentrated on addressing deprivation and social justice from a radical approach in the traditions of Harvey and Peet. Iyun (1989:35) describes Okafor's (and another pioneer, Egunjobi's) interests thus:

> …while Okafor, for instance is more concerned with location/allocation problems to answer questions on efficiency and social justice, Egunjobi is more interested in characteristics of healthcare resources and their implication for regional planning.

Okafor's medical geography works which are within the healthcare segment (Okafor, 1979, 1987, for instance) have provided the left's perspective to medical geography. In any case, these scholars represent two traditions of medical geography from their research. While Okafor and Shehu represent the healthcare tradition, Iyun promotes the disease ecology tradition. We are therefore left with no one promoting the nutrition tradition until much recently, as we will see later.

No work on medical geography in Nigeria would be complete without discussing the late B. Folasade Iyun. See, for instance, Iyun (1984a, 1984b, 1984c, 1987, 1989, 1998), Iyun et al. (1995). During her life time, she carried the flag of this subdiscipline even when it was seen by many as a 'borderline discipline'. In her account (Iyun, 1998:224) of teaching medical geography in Nigeria she says,

> It is a matter of joy but with great personal humility to state that the beginning of contemporary medical geography in Nigeria can be traced to the personal interest of the present writer during her undergraduate days in Ibadan. This was promoted by the personal search for an 'unusual' topic for the traditional Ibadan original essay. Dr (later Professor) Hyacinth I. Ajaegbu had been kind enough to have volunteered to supervise the essay entitled 'the effect of distance on the utilization of health care in Ilaje district'.

This shows how from the beginning, Iyun developed an interest in this 'unusual topic' which, in the end, would be her calling. She continued to pursue this field until she got a PhD and later devoted all her time teaching and propagating medical geography until she became associated with it. Once the name Iyun is mentioned in the geography circle, medical geography comes to mind. Although we could not lay our hand on her CV to do more justice to her profile, Iyun supervised many master's dissertations, including Adamu and Babatimehin, co-authors of this chapter, and Oguntoke as well as many doctoral theses in medical geography at Ibadan and the University of Louisville, USA. She was instrumental in sustaining the teaching and in inspiring students to specialize in medical geography. Her efforts at pioneering and promoting medical geography were unwavering; she became like the ambassador of the discipline until her passage in 2003 at 58.

In 1992, she organised an international conference on *Health Issues in Development* at the University of Ibadan under the auspices of the IGU Commission on Health and Development. Thirty-seven papers were presented at the conference, and a book of proceedings consisting of 25 selected papers was published as *The Health of Nations. Medicine, Disease and Development in the Third World*, which she co-edited with Yola Verhasselt and Hellen, J.A. That was the first and, so far, the last time such a conference was organised in Nigeria. The papers were grouped into five sections: health consequences of environmental changes, urbanization and health, changing lifestyles, women and health and healthcare provision in a Third World Context, Pringle (1997). In a personal communication at her home in Louisville, USA, with Adamu (the first author, who was a Fulbright Fellow at the School of Public Health, University of Alabama at Birmingham, 2001–2002), Iyun confessed that it came as a surprise to her when Adamu came all the way from Northern Nigeria to the University of Ibadan (in Southwest Nigeria) to specialize in medical geography and that, that made her very happy. Unknown to her Adamu would be another seed that would sprout and ensure the continuation of her dream in ensuring the growth of medical geography in Northern Nigeria. In recognition of her pioneering works in medical geography, Iyun served as a vice president of the International Geographical Union between 1992 and 2000.

Dora J. Shehu is a West African who has also contributed to the promotion of medical geography in Nigeria. She worked on the spread of schistosomiasis haematobium along the Volta Lake in Ghana in 1975 for her master's programme and worked on *Needs Assessment for Health Services provision in Central Region, Ghana*, for her doctorate degree in 1983–1984. She pioneered the teaching of medical geography at Usmanu Danfodiyo University, Sokoto (UDUS), in Northwestern Nigeria and stayed on till 2004. Due to lack of interest in the field of medical geography and very low intake of postgraduate studies at UDUS, she was unable to have doctoral candidates but has inspired many to develop interest in the area, including Adamu, whose interest is in maternal health, and another doctoral student who focused on occupational health. She has however worked with many physicians to create awareness on the role of geographers in the study of health and disease. She worked with many government and development agencies such as the WHO, World Bank, UNICEF (United Nations International Children's Emergency Fund) and USAID (US Agency for International Development) and has created goodwill for geographers and social scientists in the health sector.

Her work concentrated on promoting reproductive health in Africa focusing on maternal morbidity and mortality reduction and provision of emergency services to reduce maternal deaths through an established organization for the prevention of maternal deaths. Iyun (1998:226) presented Shehu's contributions as follows:

> It must also be said that a few others especially the Sokoto group working at the Usmanu Danfodiyo University, have made a significant contribution in promoting the multidisciplinary approach of medical geography. Dr. Dora Shehu in particular has collaborated with health practitioners in gynaecology and obstetrics at the University Teaching Hospital, Sokoto on the prevention of maternal mortality in Sokoto and Kebbi States, Nigeria, sponsored by the Carnegie Corporation of New York. She has also been involved in adapting the case study approach to elucidate the socio-cultural factors that influence the impact of EPI (expanded programme on immunization) on the incidence of immunizable diseases.

Prof Shehu's participation in the Carnegie Foundation project on the Prevention of Maternal Mortality Programme in 11 countries in Africa, which later expanded to 22 countries, brought medical geographers to the fore and got them involved in the programme in Nigeria and other countries in Africa. She was a regional coordinator for the Prevention of Maternal Mortality programme in Africa between 2005 and 2011 and the Africa region representative for the commission of Geography for Health for the International Geographical Union from 1995 to 1998. Her work has meant collaboration with many physicians to create awareness on the role of geographers in the study of health and disease. She assisted the *Journal of Social Science and Medicine* to peer review articles on medical geography (Plate 3.1, 3.2, and 3.3).

Plate 3.1 S.I. Okafor (Asaba Memorial Blog (2011))

Plate 3.2 B.F. Iyun (Department of Geography, University of Ibadan Repository (1990))

Plate 3.3 D.J. Shehu (Shehu, D.J. (Personal Communication, 9th May, 2023))

The growth of the sub-discipline was slowed down in this period because of many factors. Some of these included the following:

(i) Lack of support and recognition of medical geographers by other geographers teaching in the universities. This attitude discouraged many geographers from specializing in the area. Based on a discussion with the late Iyun in 2002 at her home in Louisville, USA, she narrated her ordeal at Ibadan because some of her colleagues had not taken medical geography to be 'a serious' branch of geography.

(ii) Resistance from professionals in the medical field and lack of proactive effort by geographers to reach out to health specialists. Geographers interested in disease/health are seen as a threat by some health practitioners, especially physicians whose strong territoriality is a major setback to geographers wishing to contribute to the health sector. Many times, they got discouraged.

(iii) Lack of interest by undergraduate students in registering for the course because they perceived it as difficult.

(iv) Dearth of specialists in medical geography to train students, especially at the postgraduate level.

3.3.3 The 1990s: The Latency Phase

In the 1990s, the University of Ibadan, where Okafor and Iyun were affiliated with, remained the centre of medical geography training in Nigeria. By the late 1990s, the training of medical geographers cascaded down to younger geographers trained by the duo and Shehu. When Adamu, trained and mentored by Iyun and Shehu, was employed by the Bayero University in Kano, Northern Nigeria, in 1995 as an assistant lecturer in geography, his first attempt was to introduce medical geography in the course curriculum of the Department of Geography; he was not successful until the 1997/1998 academic session. However, he influenced five of his students to work on medical geography topics in the 1994/1995 session even before the course was introduced in the department. Consequently, the following research essays were produced:

(i) Spatio-temporal Patterns of Cerebrospinal Meningitis in Urban Kano, Nigeria by Usman Rabiu Mudi
(ii) Tuberculosis in Urban Kano: A Geographical Perspective by Tolani F. Abayomi
(iii) Spatio-temporal Patterns of Sickle-Cell Disease in Urban Kano by Abubakar Umar
(iv) Spatio-temporal Patterns of Measles in Urban Kano, Nigeria, by Muhammad A. Sule
(v) The Utilization of the Maternity Unit of Uturpko General Hospital, Benue State, Nigeria, by Solomon Okopi

The students scored high marks not only because of the good supervision they received but because they worked on new areas and external examiners found this interesting. This helped attract the interest of other students to register for medical geography in the subsequent years and write their bachelor's projects in the area in Bayero University, Kano (BUK). Adamu continued to promote the sub-discipline, interacting with physicians and attending health conferences. In addition, Adamu being a creative writer always includes his specialty when he writes about himself on the cover of his books. This has over the years created awareness about the existence of medical geography.

3.3.4 2000–Date: The Expansion and Popularization Phase

In this phase, the works on medical geography continue at BUK with the students of Adamu. Because Bayero University had no postgraduate programme in geography up to 2008, the university had concentrated on its famous Land Resources Programme which was initially funded by the Ford Foundation under the late

Professor Michael Mortimore. It became very hard to have students interested in doing research on health in the Land Resources Programme which concentrated on land administration and land development. However, within this period, only three master's students were interested in health and were supervised under the master of Land Resources Administration programme by Adamu, as follows:

(i) Abubakar, M. (2008) Housing and Disease Patterns in Keffi, Nassarawa State, Nigeria
(ii) Dardau, H. (2011) Distribution of Health Facilities in Katsina State, Nigeria
(iii) Sheshe, F.I. (2011) Distribution and Utilisation of Health Facilities in Tofa Local Government Area (LGA) Kano State, Nigeria

This slowed the training in the sub-discipline at the postgraduate level until Adamu registered for a PhD that specialized in medical geography. Like with Iyun, there was no trained medical geographer to supervise him at BUK; he was therefore supervised by a professor of the Rural Geography (Professor J. Afolabi Falola). The story is similar with many other medical geographers in other universities in Nigeria. After the completion of his thesis (which was examined by Professor Dora J. Shehu) and his promotion to the rank of senior lecturer, he began to promote and attract postgraduate students to specialize in the area. Luckily enough, he got Abubakar K. Monguno, to be his pioneer doctoral student. Monguno worked on immunization coverage in Borno State. From 2010 to date, Adamu has successfully completed the supervision of over ten doctoral students who specialized in medical geography at Bayero University, Kano. Elsewhere, Babatimehin at the Obafemi Awolowo University Ife has also successfully completed the supervision of three doctoral candidates in medical geography. Doctoral training in medical geography is gradually growing in Nigeria. With an increasing number of senior lecturers in medical geography, many more students will be produced.

3.4 Training of Medical Geographers

Although the teaching of medical geography in Nigeria started at the University of Ibadan in the 1980s (Iyun, 1998), the teaching of medical geography in many Nigerian universities is recent. It is usually a third- or fourth-year elective course. Students who wish to write their final year research work in the area have to register for the course. Postgraduate students can also specialize at MSc or PhD levels in some universities. Table 3.1 shows the list of universities where medical geography is being taught at different levels.

Table 3.1 Some Nigerian universities with programmes in medical geography

Sno	Institution	State	BSc	MSc	PhD
1	Adamawa State University, Mubi	Adamawa	✓		
2	Ahmadu Bello University, Zaria	Kaduna	✓	✓	
3	Bayero University, Kano (BUK)	Kano	✓	✓	✓
4	Benue State University, Makurdi, Benue	Benue	✓		
5	Federal University, Kashere	Gombe	✓		
6	Federal University, Gusau	Zamfara	✓		
7	Federal University, Gashua	Yobe	✓		
8	Gombe State University	Gombe	✓	✓	
9	Imo State University, Owerri	Imo	✓		
10	Kaduna State University	Kaduna	✓	✓	
11	Kano University of Science and Technology, Wudil	Kano	✓	✓	✓
12	Modibbo Adama University, Yola	Adamawa	✓		
13	Nassarawa State University, Keffi	Nassarawa	✓	✓	✓
14	Nigerian Army University, Biu	Borno	✓		
15	Obafemi Awolowo University, Ife (OAU)	Osun	✓	✓	✓
16	Sokoto State University	Sokoto	✓		
17	Umaru Musa YarAdua University, Katsina	Katsina	✓	✓	✓
18	University of Abuja	Federal Capital Territory	✓	✓	✓
19	University of Ibadan (UI)	Oyo	✓	✓	✓
20	University of Ilorin	Kwara	✓	✓	✓
21	University of Maiduguri (UniMaid)	Borno	✓	✓	✓
22	University of Uyo (Uniuyo)	Akwa Ibom	✓	✓	✓
23	Usmanu Danfodiyo University, Sokoto (UDUS)	Sokoto	✓	✓	✓
24	Yobe State University, Damaturu	Yobe	✓		
25	Yusufu Maitama Sule University, Kano	Kano	✓		
26	Federal University of Agriculture Abeokuta	Ogun		✓	✓

Source: Nigerian Medical Geography Network and Interviews 2022

3.4.1 Undergraduate Training

There is no single or common course description for the course in the universities where it is offered. However, there are similarities in what is being taught. Disease ecology and healthcare are mostly covered while nutrition is rarely taught. Below are some examples of universities teaching the course and the course descriptions. The sample course descriptions from four of Nigeria's six geo-political regions, namely, northeast, south-south, southwest and northwest, provide a summary of what is being taught:

Nature, method and scope; the geography of diseases – indices, vectors, biophysical factors, population;cultural practices and nutrition; world patterns of health and economic development; regional studies of the effects of waste disposal, water supply and pollution on health; World Health Organization, health delivery services; rural and urban health; public health administration and planning in Nigeria, local studies; world pattern of diseases such as HIV/AIDS, cholera and Ebola; and migration and disease spread.

University of Uyo – Concept and scope of medical geography, geographic patterns of morbidity and mortality in the past and present, diffusion of disease in the third world with emphasis on Nigeria, modern versus traditional medicine, primary healthcare and distribution of health facilities

Obafemi Awolowo University, Ile-Ife – Essentials of medical geography: introduction to medical and health geography; history of medical geography; questions, concepts and data sources in medical geography; concepts of health and disease; epidemiological terminologies; demographic and epidemiological transition; disease ecology: the human ecology of disease; spatial analysis of health and disease mapping; the geography of vectored and non-vectored diseases; emerging and re-emerging diseases; spatial diffusion of disease; health delivery and planning; and applications of GIS in health.

Bayero University, Kano – Ancient origins of medical geography over the centuries up to the twentieth century; concepts of health and disease and epidemiological terminologies; theories and models – the germ theory, health field model and disease ecology; changes in mortality and fertility and diseases using both demographic and epidemiologic transition theories; infectious and non-infectious diseases; emerging and re-emerging diseases; impact of changes in agriculture on human nutrition and human health, the nutritional transition and its influence in the emergence of chronic disease; classification of health facilities, spatial distribution, location, access and utilization of healthcare services; maternal health and access and utilization to antenatal and obstetric care services; methods used in medical geographic studies, mapping and visualization of health information (GIS); and the collection and interpretation of health data.

Evidently, the universities do not have similar contents and emphasis seems to be divergent. We can pinpoint the domains of disease ecology and healthcare delivery where the course material converges. There are variations in the depth, particularly with regard to disease ecology. For instance, universities such as BUK and OAU go beyond these two to further research emerging and re-emerging diseases and their determinants, whereas many of the institutions restrict themselves to infectious and non-infectious diseases. Disease diffusion, which is only examined at Uniuyo, is another startling distinction. The third segment of medical geography (nutrition) is covered by BUK and UniMaid. By and large, the course descriptions adequately cover the fundamental knowledge needed to understand medical geography as a branch of geography. There may be a need for the lecturers to update and harmonise the curriculums so that students can be taught similar curriculum.

3.4.2 Postgraduate Training

There is a growing interest in medical geography by students at master's and doctorate levels in Nigerian universities. This may be attributed to the increase in the number of lecturers specializing in the area and also increasing needs for studies to address health problems in Nigeria. Nigerian universities are now training master's and doctoral students in the field and the numbers are pleasantly increasing. In some universities, there may not be a trained medical geographer to supervise doctoral candidates; however, an experienced professor of population or human geography usually supervises such students. In some universities where there is a joint supervisory team, senior hands or professors are invited from community health/epidemiology or other departments like biology, sociology or economics to serve in the supervisory team. There may not be courses taught at some levels in some universities, such as master's levels, but there are students interested in writing their thesis or dissertations in the area because there are specialists. It is however important to note that there is an increasing number of trained medical geographers in these universities who are working hard to strengthen teaching and research in the area, and this, in itself, is encouraging.

Training of doctoral candidates assists in providing manpower to introduce, promote and train students at all levels in Nigerian universities. From 2002 to 2021, there is a harvest of doctoral candidates in the sub-discipline as shown in Table 3.2. Although the list may not have included all the doctoral works done between 2002 and 2021, the list was based on the information available to us from Nigerian Medical Geography Network. It represents over 80% and can be considered a good representation of the research interests of doctoral candidates. From the list, it is obvious that there is competing interest on the two traditions, namely, disease ecology and healthcare, but it is also comforting that the nutrition tradition is now receiving attention.

3.5 Research Interests and Contributions of Nigerian Medical Geographers to Health Research in Nigeria

Medical geographers have contributed and are still contributing to the body of health research in Nigeria. The body of work is huge with contributions made in peer-reviewed journals, both local and internally acclaimed, and also captured as book chapters and proceedings of conferences. The works are widely distributed in geographical, social science, environmental and medical journals within Nigeria and beyond and have been cited by geographers, physicians, public health practitioners, social scientists and other specialists around the world.

Table 3.2 Select bibliography of doctoral theses in medical geography in Nigeria, 2002–2021

S/N	Author	Thesis title/year	Awarding institution
1	Adamu, Y.M.	A Geographical Analysis of Maternal Mortality in Kano State, Nigeria	Bayero University, Kano, 2004
2	Adewoyin, Y.	Analysis of Spatial and Temporal Patterns of Malaria Prevalence in Ibadan, Nigeria	Ladoke Akintola University of Technology, 2015
3	Aji, Y.S.M	Spatio-temporal Assessment of Under-Five Mortality Determinants in Borno State	University of Maiduguri, 2014
4	Akawu, C. B.	Geospatial Analysis of Malaria Prevalence and Vulnerability in Borno State, Nigeria	University of Maiduguri, 2021
5	Aliyu, I. A.	A Geographical Analysis of Typhoid Fever in Kano State	Bayero University, Kano, 2019
6	Amhanyunonsen, A.J.	Spatial Pattern and Utilization of Primary Health Care Facilities in Edo State, Nigeria	University of Ibadan, 2013
7	Awe, G.T.	Distance Thresholds for Health Care Facility Utilization in Rural Districts of Ibadan, Nigeria	University of Ibadan, 2014
8	Babatimehin, I.O.	Spatial Analysis of Onchocerciasis Prevalence and Perception in Pategi Local Government Area, Kwara State	University of Ibadan, 2005
9	Danbuzu, L.A.S.	A Geographical Analysis of Tuberculosis in Kano State, Nigeria	Bayero University, Kano, 2021
10	Dardau, H.	A Radical Perspective on the Location and Utilization of Health Services in Katsina State, Nigeria	Bayero University, Kano, 2021
11	Fada, A.G.	Nomadic Pastoralism and the Prevalence of Pulmonary Tuberculosis in the North-Western Region of Nigeria	University of Ibadan, 2015
12	Fadahunsi, J.T.	Spatial Analysis of Accessibility and Utilisation of Healthcare Facilities in Osun State, Nigeria	Obafemi Awolowo University, Ile-Ife, 2016
13	Ibor, U. W.	Spatial Pattern and Perception of Urinary Schistosomiasis in Cross River State, Nigeria	University of Ibadan, 2017
14	Jesutowo, I.D.	Evaluation of Habitat Suitability for Mosquitoes and the Risk of Malaria among Residents of Ondo State, Nigeria	Obafemi Awolowo University Ile-Ife, 2018
15	Kolo, M.A.	A Geographical Analysis of Maternal Mortality in Borno State	Bayero University, Kano, 2015
16	Lawal, U.	A Geographical Analysis of Cholera in Adamawa State	Bayero University, Kano, 2015
17	Monguno, A.K.	A Geographical analysis of Immunisation Coverage in Borno State	Bayero University, Kano, 2010
18	Muibi, K.H.	Spatial Analysis of Meningococcal Meningitis Occurrence in the Sudano-Sahelian Ecological Zone of Nigeria	Obafemi Awolowo University Ile-Ife, 2018
19	Oguntoke, Olusegun	A Geographical Analysis of Cancer Incidence in Nigeria	University of Ibadan, 2002

(continued)

Table 3.2 (continued)

S/N	Author	Thesis title/year	Awarding institution
20	Osayomi, T. A.	Geographical Analysis of Diabetes in Oyo State, Nigeria	University of Ibadan, 2017
21	Raheem, U.A.	Influence of Deprivation on the Health Status of Residents in Ilorin, Nigeria	University of Ibadan, 2012
22	Salubi E. A.	Spatio-Temporal Patterns of Cholera Incidence in Nigeria	University of Ibadan, 2018
23	Sani, M.	Location and Utilisation of Health Services in Sokoto State, Nigeria	Bayero University, Kano, 2021
24	Uriri, A.E.	A Spatial Analysis of Maternal Mortality and Human Development Indicators in Delta State	University of Lagos, 2014
25	Uzoma, E.I.	An Analysis of the Utilisation of the Expanded Programme on Immunisation (EPI) in Akwa Ibom State, Nigeria	University of Uyo, 2018
26	Yayaji, B.A.	Location and Utilisation of Maternal Health Services in Gombe State	Bayero University, Kano, 2016
27	Zakari, N.	A Geographical Analysis of Cerebrospinal Meningitis in Kano State, Nigeria	Bayero University, Kano, 2021

3.5.1 Research Interests and Contribution to the Field

Starting with the healthcare segment, it is not surprising that there is interest in maternal and child's health. We can see works on maternal mortality from both northern and southern parts of the country which have examined not only the obstetric and non-obstetric causes of maternal deaths but also rural and urban differences in maternal mortality rates and ratio. The studies were able to provide the spatial and temporal patterns of maternal death using health facility-based data. For instance, Adamu (2004) shows the zonal variations of maternal mortality ratio in Kano State (1990–1999). The study found that Kano State had an average maternal mortality ratio of 2420/100,000, with spatial variations between the zones in the State. For instance, Kano North-West had the highest maternal mortality ratio of 4477/100,000, and Kano North Central zone had a MMR of 3104/100,000, while Kano Central and Kano Southwest had MMR of 1373/100,000 and 3104/100,000, respectively. Interest in healthcare is not restricted to only maternal health but extends to child's health too, with emphasis on under-five mortality, immunization coverage and the utilization of the Expanded Programme on Immunisation (EPI). Nigeria was notorious for high infant and child mortality and for resisting immunization. The studies are also across the north and southern part of Nigeria. Uzoma's (2018) work in Akwa-Ibom State, Southern Nigeria, using utilization index map shows an inequality in the utilization of immunization services between local government councils in the State and that socio-economic variables have an influence on the use of immunization services.

Spatial distribution and pattern of health facilities and/or services and their utilization have always been central to geography. This interest has been sustained by medical geographers in Nigeria. There were doctoral works across the country on both primary and secondary health services utilization. These studies used mixed methods and also used GIS as a tool of analysis. Studies covered Sokoto, Katsina and Ilorin in the north and Edo State in the south. Some used the radical perspective influenced by Okafor's works. The work by Raheem (2012), for instance, found that multiple deprivation was concentrated in the inner parts of Ilorin City (North Central Nigeria) compared to wards in the suburbia where housing quality was better. The inner city remains an area of poor housing quality and high levels of deprivation which significantly affected health status of residents. In his work, Sani (2021) found that the distribution pattern of healthcare facilities in Sokoto State, Northwestern Nigeria, was clustered, not equitably distributed across the local councils, and that modern healthcare facilities were more utilized in urban areas while traditional healthcare was more accessible in rural areas.

The disease ecology tradition is also attracting postgraduate researchers, and their research interest is on diseases of public health importance. Malaria, a major tropical disease and one of the major causes of death in Nigeria, has received attention. There are studies from northern and southern parts of the country such as Borno, Ondo and Oyo States (Akawu, 2021; Jesutowo, 2018; Adewoyin, 2015). These studies look at the spatial patterns and prevalence of malaria as well as the environmental determinants of its distributions. Under this tradition, studies on infectious diseases like tuberculosis and cerebrospinal meningitis have also received attention, especially in the northwestern and southwestern regions of Nigeria. For example, in a study in Kano State, Danbuzu (2021) re-asserts that tuberculosis still remains the disease of the urban poor because the metropolis had the highest number of cases in counts, incidence and prevalence which decay with distance away from the metropolis. There is also seasonal variation in the incidence and occurrence of the disease in the study area.

Water-borne diseases such as cholera, typhoid fever, onchocerciasis and urinary schistosomiasis have also received attention. Lawal's (2015) work on cholera in Adamawa State examined the spatial and temporal patterns of cholera cases during an outbreak that occurred in Mubi town of Adamawa State of the northeastern region of Nigeria in 2009. The study also examined the diffusion of cholera in Adamawa State and discovered that cholera diffusion pattern expanded outwards through contacts from rural to urban areas in 19 of the 21 local government areas (LGAs) in the state. The author also found that relocation diffusion was responsible for the spread of the disease from Jigawa State (northwestern region) to Adamawa State. The study identified poor drinking water sources and open defecation in rural areas of the state as a major predisposing factor for the spread of cholera. Another study by Salubi (2018) examined the spatio-temporal patterns of cholera incidence in Nigeria from 1970 to 2013. There is also a work on typhoid fever in Kano State by Aliyu (2019) which revealed that the disease was highly prevalent in both metropolitan and non-metropolitan LGAs, with clusters being seen during the course of the ten-year study period with a case fatality rate of 6%.

Due to health transition, chronic diseases are becoming increasingly important, and there is slow but growing interest on such diseases as diabetes, cancer and cardio-vascular diseases. Osayomi's (2017) work on diabetes in Oyo State, Southwest Nigeria, using both health facility-based data and primary data, established that in the state, the incidence of diabetes varied significantly across the LGAs and was closely related to the LGAs' level of development. Hotspots were found in Akinyele, Ibadan North, Ibadan Northwest and Lagelu LGAs. Three candidates are also working on cardio-vascular diseases in northwestern, northeastern and north-central regions of Nigeria. Currently, there seems to be expansion and diversification on areas of interest by doctoral students specializing in medical geography in Nigeria universities; for instance, in BUK, there are doctoral candidates now working on the neglected tradition of medical geography, namely, Faiza Isa Sheshe (a co-author of this paper) is working on the geographies of child's malnutrition in Kano State. Based on her progress report, her study finds a clustered distribution pattern of child's malnutrition with high prevalence in both metropolitan and nonmetropolitan LGAs such as Kumbotso, Wudil, Municipal, Dala and Tofa, Tsanyawa and Madobi LGAs. This is in addition to two other candidates working in the area in northwestern and north-central regions of Nigeria. There are also candidates working on mental health geographies, spatial perspective of eye diseases and geographic study of dental cares in Northwestern Nigeria.

It can be argued that research by medical geographers has helped in the reduction and/or solving some health problem in Nigeria. For examples, geographers in Ibadan contributed in the control of cholera outbreak in some parts of the city in the 1980s. So also, Adamu's studies on maternal mortality in Kano State have contributed hugely in the reduction of maternal mortality in the state, especially those due to eclampsia. His study established that eclampsia was the major obstetric cause of maternal death (31%) in the state from 1990 to 1999. The study attracted the attention of the Population Council of New York. The then Country Director of Population Council, Dr. Andrew Karlyn, invited Adamu to the launching of its intervention on the use of magnesium sulphate ($MgSO_4$) for the treatment of eclampsia in 2009. That has contributed immensely in reducing maternal death due to eclampsia as, of 1045 patients with eclampsia and pre-eclampsia during the years 2008 and 2009, there was a drop in case fatality rates from 20.9% to 2.3% among eclampsia patients following the $MgSO_4$ intervention (Okereke et al., 2012).

The body of work is enormous and the foregoing is just a glimpse. We have listed some select bibliography of works on medical geography by Nigerian geographers between 1975 and 2021 in Appendix 3.1. The magnitude of works, notwithstanding the pace of impacts, has been slow. The slow pace in the impact of researches in the sub-discipline in healthcare development in Nigeria might not be unconnected to the disconnect that exists between the researchers and policymakers. While the research institutions are funded, largely, by the government, researches from these institutions are rarely used in policy formulation.

3.6 Technological Advancements in Medical Geography Studies in Nigeria

The use of maps is central to all geographic studies. As far back as the seventeenth century, maps have been used to describe spatial variations of disease. Meade and Emch (2010) have shown how Koch (2005, cited in Meade and Emch, 2010) provides a meticulously documented history of disease mapping, from the Naples plague in the 1690s. This means that the famous map of cholera in London by John Snow (which is always seen as a turning point in the use of disease maps) is not the first but a common example of how maps are used to depict disease distribution and the importance of the use of maps in medical geography. Howe (1986) argues that maps provide an efficient and unique method of showing distributions of phenomena on space including diseases. Maps continue to be the virtual tool for presenting geographical data including health and disease data sets. In Nigeria as elsewhere, medical geographers make of use of maps to show distributions, patterns of diseases or health facilities in their works. Without maps, spatial expressions hardly make sense. This is why medical geographers use maps. Using some examples, we will show the gradual growth and complexity of the use of maps in medical geographic studies in Nigeria.

In the past, for instance, manual cartography to present graphical data and dots maps, choropleth maps and flow maps are used to show data. In recent years, computer cartography and Geographic Information System (GIS) have provided new tools to display health and/or disease data over space, allowing endless possibilities for data manipulation and providing detailed information that would have been impossible to generate in the past. As explained by Meade and Emch (2010), with the help of GIS, disease maps can now display the results of sophisticated spatial analytical operations. For example, Babatimehin (2005) used a flow map to depict the patterns of migration from an onchocerciasis endemic area as shown on Fig. 3.1 while Muibi (2018) used GIS to show the flow of TB patients to a health facility in Fig. 3.2. While manual cartography hardly allows one to depict more than two layers of information, GIS allows you to present multiple layers of information. Therefore GIS allow us to do more complex analysis by creating endless possibilities of superimposing different layers of data to create a visual presentation of some parameters.

Figure 3.4 is another example of how advancement in technology gives us opportunities to see and say more, as well as manipulate health and spatial data with ease. While Fig. 3.3 shows just two layers of information in the figure, namely, different perceptions within a delimited area (polygon), Fig. 3.4 shows age distribution by location in addition to hot spots of diabetes in metropolitan Kano as a well as the names of the locations. In this study, Hassan (2016) was able to superimpose age category map on the spatial distribution map, which indicated a significant difference between the age groups and spatial distribution of diabetes mellitus cases (Fig. 3.3). The figure shows how diabetes cases are higher in the core city than periphery because of the affluent nature of the lifestyle in the city. This may not be

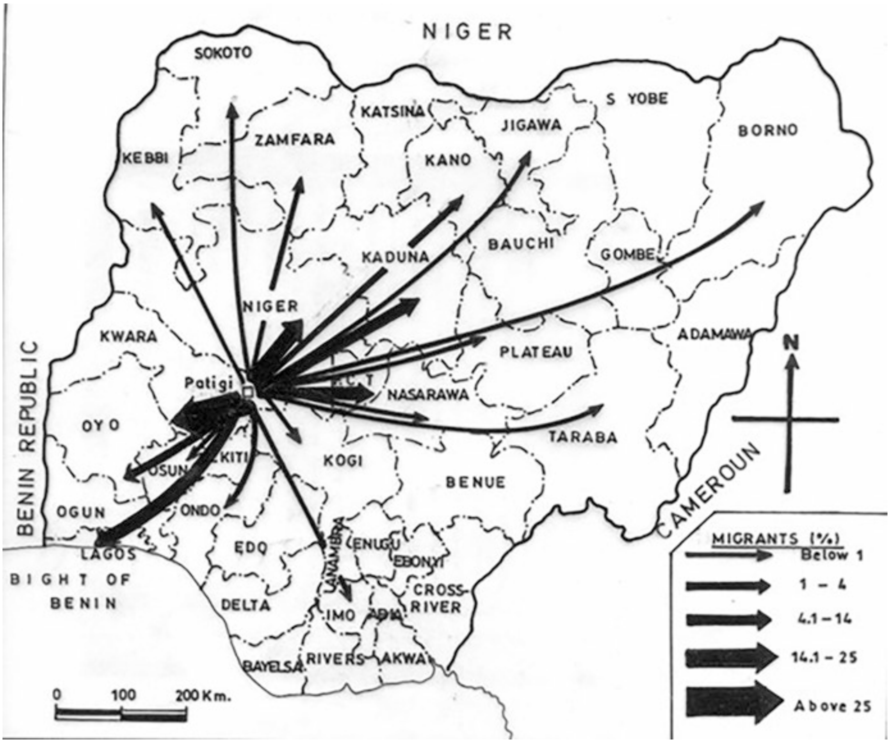

Fig. 3.1 Migration flow from Patigi LGA, Kwara State, Nigeria

easy or possible using simple cartographic tools used in the past. Both students and researchers make the maximum use of computer cartography and GIS and even remote sensing in their analysis, and these allow researchers to see more and provide detailed explanations of spatial health data.

3.7 Challenges and Prospects

Medical geography and medical geographers are facing some challenges which, in many ways, affect the sub-discipline's growth and progress. Some of the major ones are as follows:

(i) *Nature of data in medical geography*: Since medical geographers use location-specific data, it is often difficult to get the exact location of patients. This is because some patients hardly go to a health facility, so they cannot be captured. Where they visit health facilities, in some cases, their addresses are not captured. Sometimes the addresses are captured but are found to be unreliable. For instance, where a patient states his LGA of residence rather than his street or neighbourhood, it becomes difficult to get the right scale for analysis.

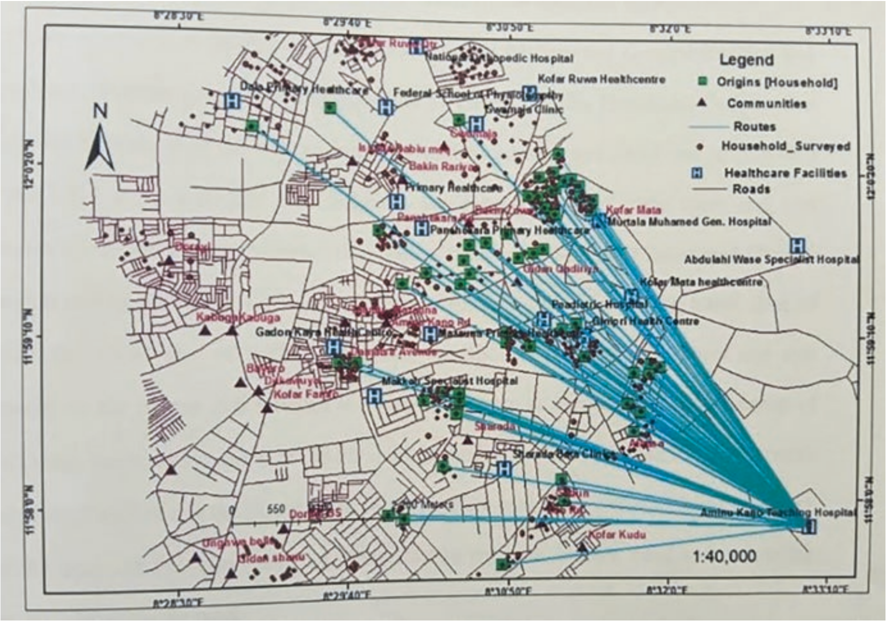

Fig. 3.2 Flow patterns of residents to Aminu Kano Teaching Hospital, Kano

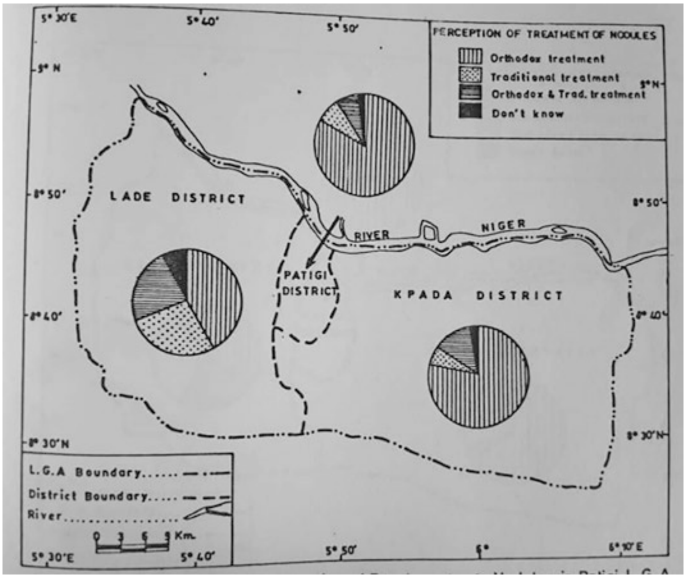

Fig. 3.3 Spatial pattern of perception of treatment of nodules in Patigi local government, Kwara State

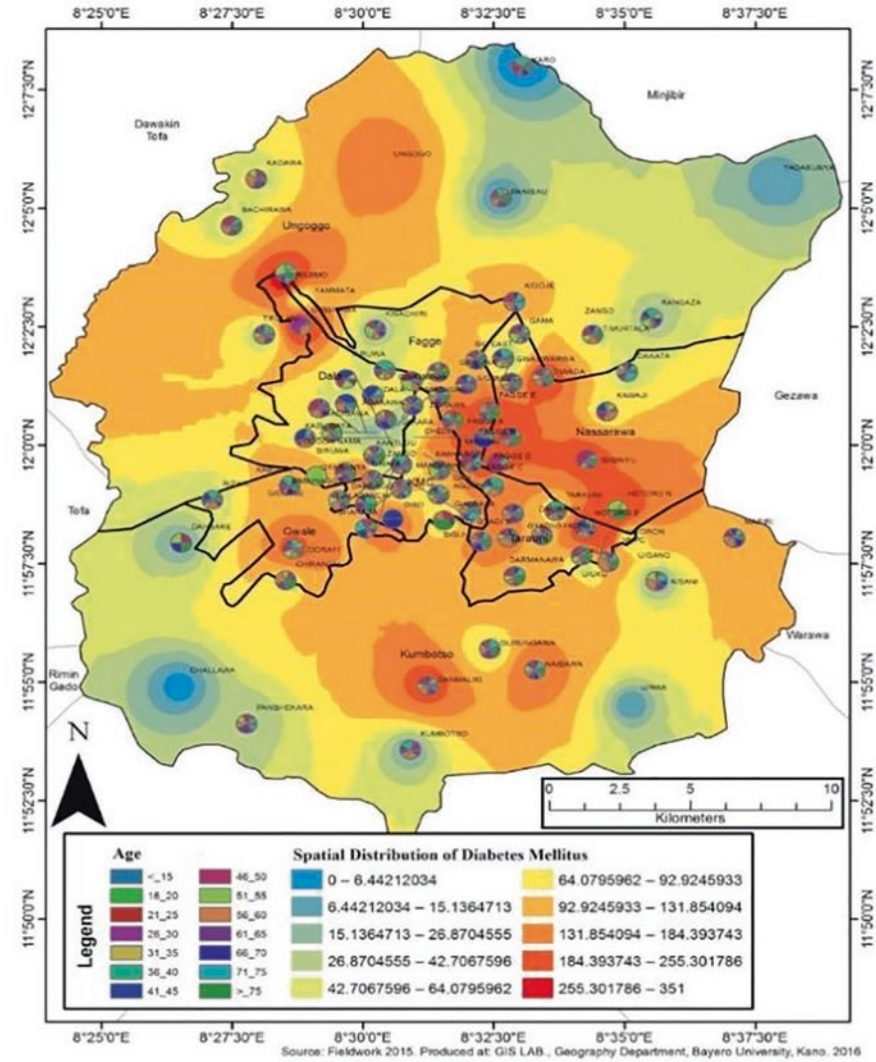

Fig. 3.4 Age and spatial distribution of diabetes mellitus superimposed

(ii) *Availability and accessibility of data*: There is a dearth of health facility-based data. Even where it exists, it is often very difficult to access. In addition, there are many gaps in the data. Whereas data in private health facilities are almost inaccessible to researchers, poor record keeping is a significant issue for many public health facilities. Patients' case files are still used for patients, and records are mostly stored in analog forms. Incomplete patient registers are a frequent problem in the hospital, and the registration records are not properly preserved as such. When records are lacking, researchers turn to patient case files, but these files are similarly vulnerable to poor storage conditions that can cause destruction by mice, termites or even rainwater.

Another issue is that there is not enough room for case files and documents, which leads to missing, damaged and misplaced items. These case files are sometimes transported to other locations, such as facility libraries or even the morgue, where they are dumped like trash and eventually become scattered or lost. Additionally, health records are not given the necessary attention they deserve because they are often not used by the management and other policy makers.

(iii) *Weak collaboration with health professionals:* Another significant obstacle is the lack of cooperation/collaboration with health professionals. It is often difficult to get health professionals to collaborate with geographers in research. In some cases, there is the territoriality syndrome where physicians, for instance, see other health researchers as a threat. This is gradually changing though due to the proactive approach used by medical geographers in addition to the need for interdisciplinary requirements for studies in healthcare.

Given the growth of the field at the undergraduate and graduate levels, medical geography has a promising future in Nigeria. The number of institutions offering teaching and conducting research is likewise rising. Additionally, non-geographers, particularly those working in the field of medicine, are starting to understand how crucial it is for improving public health. Even though it has taken ages, there seem to be openings for collaborations between medical geographers and health professionals. For example, medical geographers in BUK are currently teaching postgraduate courses in public health, obstetrics and gynaecology. They are also invited to meetings and to develop research proposals in other health-related fields. At the moment, medical geographers in BUK are involved in the following research proposals:

(a) *An Appraisal of the Heat Adaptation Strategies to Mitigate the Incidence of Preterm Birth (PTB) in Kano State, Nigeria*, has been submitted to the Wellcome Trust, UK. This research is jointly facilitated by the African Centre of Excellence for Dryland Agriculture and African Center of Excellence for Health and Policy, all, at BUK.
(b) *Investigating the prevalence and factors associated with Hearing Impairment among Generator workers in Northern Nigeria.* This is another proposal submitted to the National Research Fund. This is a collaborative research with members of staff of the Community Health and the Otolaryngology Departments, BUK.
(c) *Development of a multi-adaptor quality control kit for integration with radiographic equipment.* This is also another proposed research submitted to the National Research Fund in conjunction with staff from physics, mechanical engineering, radiography and electronics departments.

Until recently, medical geography practitioners were not aware of one another. However, efforts by individuals have resulted in the formation of a social media group under the auspices of the Nigerian Medical Geography Research Network around 2016. The group has continued to be a forum for exchange of ideas, information and collaboration. At the moment, there are 52 participants from across the country. During the 2018 annual conference of the Association of Nigerian Geographers, the Medical Geography Study Group was formed. As at date, about five research works, emanating from the collaboration of some members of the group, have been published. It is hoped that the group would help in promoting the sub-discipline and ultimately be a very active health research group in Africa.

Some medical geographers who went to other countries for their postgraduate programmes are also making efforts to establish linkages with other medical geographers. For instance, Abdulkadir Muhammad a former student of Prof. Yusuf Adamu who worked on mental health geographies in Jigawa State Nigeria, at the University Sains Malaysia for his PhD, established the YMA Research Network, which allowed for communication with colleagues in Malaysia, Saudi Arabia, India and other countries in Asia. The collaboration is with the Geo-informatics Unit of Geography Section of the university. The network is basically a medical geography network, and members of the Nigerian Medical Geography Network are also members of this group. Through this network, a number of webinars have been conducted.

3.8 Conclusion

In Nigeria, interest in the relationship between geography and medicine has continued to grow since the pioneering works of medical geographers, largely from Southern Nigeria, notably the Universities of Ibadan and Calabar. The University of Ibadan has played a central role in the introduction, teaching and growth of medical geography in its early stage up till the 1990s. The contributions of Okafor, Iyun, Egunjobi (from the University of Ibadan) and Shehu (from the UDUS), in addition to other pioneers, set the foundation for the sub-discipline in Nigeria and have inspired younger generations of Nigerian geographers to sustain interest in the area. By the turn of the millennium, BUK has played a key role in promoting medical geography, most importantly in postgraduate training. Today, medical geography is being taught at undergraduate and postgraduate level in many universities in Nigeria. With the huge volume of works being produced in the field, relative to other African countries, Prothero's (1981) position that Nigerians lead in Africa, as far as interests and contributions in medical geography are concerned, remains valid. Hopefully, in the next few years, and in addition to this edited volume, there would be more texts on medical geography (as teaching materials in the universities) and a dedicated journal. We are also hopeful of more multidisciplinary collaborations with specialists in health and allied disciplines and look forward to medical geography students auditing some courses in these disciplines. By and large, it can be comfortably argued that despite the challenges in the past and present, medical geographers are increasingly becoming important and their contributions are being recognized in the health research arena in Nigeria.

Appendix 3.1: Select Bibliography of Works on Medical Geography by Nigerian Geographers (1975-2021)

1970–1979

Ajaebu, H. I., & Mann, C. E. (1975). Human population and disease factor in the development of Nigeria. In R. P. Moss & R. J. A. R. Rathbone (Eds.), *The population factor in African studies* (pp. 123–138). University of London Press.

Okafor, S. I. (1979). Spatial efficiency of public facilities. *Nigerian Geographical Journal, 22*(2), 175–184.

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Chapter 4
Traditional and Non-traditional Data Sources Useful in Research in African Health and Medical Geography

Olusesan Ayodeji Makinde

Abbreviations

CDR	Call detail records
CSD	Citizen science data
LMICs	Low-income and middle-income countries
NSOs	National Statistics Offices
SDGs	Sustainable development goals

4.1 Introduction

Data is important for identifying the determinants of health and for monitoring the interventions being carried out towards various health and development interventions including the achievement of the sustainable development goals (SDGs). Measuring the health-related SDGs can pose a challenge due to the large number of indicators that are being tracked as well as dimensions of data that are not routinely collected yet needed for a proper evaluation (Nabyonga-Orem, 2017).

National Statistical Offices (NSOs) are saddled with the responsibility of generating national statistics that can be used for evidence-based planning and decision-making by geography within their territories. However, several low-income and middle-income countries (LMICs) across Africa struggle with the generation of adequate statistics that can guide interventions in their countries. The reasons for these are diverse and often include the huge cost for collecting a wide data set that can be used to monitor a range of interventions. There are also concerns on human

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resource capacity which have been targeted by projects in the past, although gaps still persist.

Data from NSO is important to the practice of medical and health geography, especially when comparing health outcomes by location. These data are needed to appropriately make recommendations on interventions that can improve the health of people, which can vary significantly by geographic location. A collection of studies in medical geography in Africa published in 1981 highlighted the diverse opportunities for application of medical geography in health investigation and research (Prothero, 1981). The collection featured studies on application of medical geography in the field of communicable and non-communicable diseases. Case studies on schistosomiasis, measles and onchocerciasis described the application of medical geography in infectious disease research (Bradley, 1981; Ferguson & Leeuwenburg, 1981; Hunter, 1981). While case studies on mental health, nutrition and family planning described the application of this field in non-communicable diseases (Hellen, 1981; Olu Sule, 1981; Rossington, 1981; Stock, 1981; Turner, 1981; Uyanga, 1981). More recent studies continue to apply medical geography to improving knowledge about diseases and healthcare planning across countries in Africa (Adewoyin & Adeboyejo, 2016; Makinde et al., 2018; Sato et al., 2022).

NSOs or their affiliates are responsible for managing the civil registration and vital statistics systems, population censuses and routine health information systems and conducting national health surveys such as demographic and health surveys and multiple indicator cluster surveys that are popular in several low- and middle-income countries (LMICs) as well as aggregate data on service statistics across several government and service delivery units. The practice of medical and health geography traditionally relies on or assess data from these important data sources for their studies.

The outbreak of the COVID-19 pandemic however affected NSOs and their ability to meet their obligations on data generation. A survey of NSOs across LMICs by the United Nations Statistics Division and the World Bank found that many NSOs were forced to shutter and/or alter their operations as a result of the pandemic. They also realized the need for innovative ways on collecting data to measure national progress on development issues (World Bank, 2020). The inadequacy of current methods for tracking the SDGs has been highlighted in the literature (Nabyonga-Orem, 2017; Proden et al., 2022).

This chapter provides an overview of the traditional and non-traditional data sources that are important in African health and medical geography for monitoring the SDGs, especially SDG3. The chapter first highlights the traditional data sources and subsequently hones on the non-traditional data sources because these data sources are emerging and are still not well defined or adequately utilized for national statistical monitoring purposes on the African continent.

4.2 Traditional Data Sources

Before delving into the non-traditional data sources, the chapter first provides an overview of the traditional data sources and their categorization. Traditional data sources are already established data sources that are routinely used by NSOs for national health and development monitoring. These data sources have been used in monitoring the performance of the health system in different situations including monitoring the SDGs as well as national health and development plans. According to the 'Framework and Standards for Country Health Information Systems', these data sources are classified into population and institution-based data sources.

4.2.1 Institution-Based Data Sources

Institution-based data are generated from administrative and operational activities. These data include service records, individual records and resource records. The individual records are generated from documentation of healthcare services including clinical care, for example, electronic medical records or case files, growth monitoring charts and data obtained from disease registries or similar databases. The service records are usually from healthcare service providers, data from institutions such as the police, veterinary records, environmental records, insurance companies etc. and can be used to make decisions on the health system and these can contribute importantly to the assessment by NSOs. Resource records are those that include the input that are made into the health system. This can include financial records, commodity records and their distribution, health facility location data and distribution of human resources in the health space. More information on the traditional methods are outlined in the framework and standards for country health information systems (World Health Organization, 2008).

4.2.2 Population-Based Data Sources

The population-based data sources 'generate data on all individuals within defined populations and can include total population counts (such as the census and civil registration) and data on representative populations or subpopulations (such as household and other population surveys) (World Health Organization, 2008)'. Censuses involve the complete enumeration of the population in a country, territory or area and should be conducted at least once every ten years. Censuses are usually a very detailed and tasking exercise that should be adequately planned for and resourced for it to have an excellent outcome. Civil registration and vital statistics are the sum processes for recording vital events including births, deaths, marriages, divorces, adoptions and stillbirths. Population surveys are sub-sample studies that measure one or more aspects of a population. Example of surveys that are carried out in Africa include the USAID (US Agency for International Development)-supported demographic and health surveys and the UNICEF (United Nations International Children's Emergency Fund) multiple indicator cluster surveys.

The population-based data are quite expensive to collect and manage, and this affects the quality of the data available and their use in decision-making. Cost for censuses has been known to run into hundreds of millions of dollars. Thus, they are infrequently done. For example, the last official census that was carried out in Nigeria was in 2006. The next census ought to have been carried out in 2016. However, this could not be done due to unavailability of resources. Another census has been scheduled, but the estimated budget exceeds 178 billion Naira (more than 300 million US dollars) which is still not readily available for the country in 2022, 16 years after the last one was conducted.

Due to various challenges with traditional data sources, there might be room for addressing some of them by leveraging the non-traditional data sources which are emerging as new potentials for measuring progress with various development issues including the SDGs.

4.3 Non-traditional Data Sources

The non-traditional data sources unlike the traditional data sources are yet to be properly organized into any categories. Their importance however is evolving due to the increasing attention that these non-traditional data sources are receiving as well as their rapid evolution to address current and emerging data challenges in sustainable ways. The increasing availability of non-traditional data is attributed in the increasing penetration of mobile devices across the African continent. This growth has influenced the use of the Internet and access to social media across the continent. Mobile networks and social media routinely collect data on the location of the person interacting with the platform, and these data are important to their use for health and medical research purposes. This chapter groups the non-traditional data sources based on the different means by which the data are generated and convenient groups that we have identified.

As an emerging field, there are different terminologies that have been used to describe these data sources in groups and holistically. Some researchers have described the study of these data sources as digital epidemiology. According to an earlier publication, digital epidemiology is 'the use of digital data collected for non-epidemiological purposes in epidemiological studies (Park et al., 2018)'. There is an increasing body of knowledge providing different approaches to the use of these types of digital data for studying disease distribution and most importantly, to plan and take prompt action on health-related events at little cost (Salathé, 2018).

The potential of non-traditional data sources including private sector-generated data to help in filling the gap in national statistics has been pointed out by various researchers (Badiee et al., 2017; National Academies of Sciences, Engineering and

Medicine et al., 2017). A recent study highlighted how mobile phone log data could be used to monitor migratory patterns that can then be used for the targeted distribution of insecticide-treated bed nets to highly mobile individuals that could introduce the malaria protozoa into previously malaria-free zones (Badiee et al., 2017). More on this particular study is presented in the use of mobile phone records for health research section of this chapter.

Digital epidemiology data can be derived from search queries, social media posts, webpage access logs, mobile phone network data, data generated by sensors and data collected at call centres and new digital sources that are being pioneered everyday. For this chapter, the data sources are grouped into the following: citizen science or crowdsourcing, search queries, social media, mobile phone records and data from sensors. The chapter elaborates on how these data have been used for various health and development initiatives in any country and their potential application to the healthcare sector in Africa. Where these data sources have already been pioneered in Africa, such studies are presented, and lessons from their use are outlined.

4.3.1 Citizen Science

Citizen science represents an important and untapped opportunity for monitoring the SDGs. Citizen science data (CSD) is defined broadly as data produced by citizens who voluntarily contribute their time, knowledge, skills and/or their data to help produce evidence, strengthen accountability or develop locally rooted solutions (Proden et al., 2022). There are different terminologies that have been grouped into citizen science data including citizen-generated data, crowdsourcing and community-based monitoring. They are predominantly geared towards the production of data by citizens or anyone that can then be used for a collective purpose.

Citizen science data can be categorized according to five dimensions: space, time, theme, process and data management (Fritz et al., 2019). An earlier study identified four broad themes to which crowdsourcing projects could be grouped which are problem-solving, data processing, surveillance/monitoring and surveying (Ranard et al., 2014). Projects can use crowdsourcing efforts to rapidly gather data that is widely dispersed in space. There have been studies that have shown the potential for citizen science projects to provide appropriate data that is good for government decision-making (Haklay et al., 2018). Citizen science data have been used to assess surgical skills and quality of healthcare services in the United States. These have shown correlation with quality metrics from standardized quality metrics scoring programs thereby showing the promise for leveraging these methods where there are no quality scoring institutions (Perez & Freedman, 2018). However, it also raised concerns that should be considered while utilizing such measures (Synan et al., 2021).

The applicability of CSD for measuring SDGs is perhaps its most important selling point. The SDGs are to be measured by about 232 indicators which include data that are not readily available through NSOs (Fritz et al., 2019). The potential for addressing this unavailability of data through CSD has been identified and needs to be taken advantage of in LMICs.

Some citizen science projects that have been executed or in progress in sub-Saharan Africa are discussed in the following sections.

4.3.1.1 Crowdsourcing Innovations in Healthcare

Crowdsourcing innovations through challenges and hackathons has been proposed as an opportunity to tap into widespread creativity that resides in individuals for public good. Crowdsourcing contests were used to address some complex questions that have troubled researchers, and these actually reduced the time for new discovery and reduced research costs by multiple folds (World Health Organization, 2018). Thus, crowdsourcing has been adopted as a potential means for use by research teams to speed up on new innovations.

4.3.1.2 Reporta Health

Reporta Health is a mobile app for crowdsourcing data on illegal health facilities. The app was designed to leverage the master facility list or heath facility registry in countries that have developed a complete list of health facilities that are properly licensed and registered. Reporta Health helps citizens to identify and navigate to health facilities that are properly registered in the country. This infrastructure in addition provides an opportunity for citizens to report on illegal health facilities that do not appear on the app which contains a full government-approved list of facilities (Makinde et al., 2022). This will also collect GPS coordinates of the unlisted facility which can then be passed on to the government for a regulatory investigation. Reporta Health is also noted to aid with crowdsourcing rating scores on registered health facilities so that citizens can easily choose health facilities where they want to access healthcare services based on how other clients have rated the health facility. The app while noted to have been developed in Nigeria can function across any country.

4.3.2 Search Engine Queries

A search engine is a software system designed to carry out web searches. They search the Internet in a systematic way. Search engines have crawlers or bots that help with gathering data on billions of websites across the Internet and subsequently indexes and ranks these data on its own database. This helps with the speed at which the search engine returns results when a user queries for any information using that platform. There are several Internet search engines including Google, Bing, Baidu, Yahoo, Ask.com, DuckDuckGo and others. They principally are used for the same purposes.

Search engine data can provide valuable information on people's real-time activities online, their experiences, interests, concerns and misconceptions about their health and other matters of interest. These data when mined can be valuable to understanding a variety of issues. However, access to these data can also be challenging, and there can be a lot of risk of violation of the person who searches for information if such information becomes widely available. Thus, large search engines such as Google have not made data from their systems readily available for anyone to use for research.

Google is known for its very valuable search engine. Established in 1998, the company is noted to have pioneered and defined the search engine industry. The influence of the company in this domain has seen the word 'Google' adopted as a formal word for searching on the Internet. The urban dictionary provides the meaning of the phrase 'Google it' to mean 'the act of searching the internet for absolutely nothing in one's spare time'.

The availability of search engine data provides an opportunity to understand what people are searching for on the Internet. This information can be valuable to understanding what people are thinking about or what they are experiencing and use this knowledge to predict their current state of health.

Data from Google search has been used in the detection of epidemics. The Google Flu Trends (GFT) project provided an opportunity to demonstrate how the important data from search engines can predict ahead of traditional surveillance methods from the health information system and potential infectious disease outbreaks. Google search keywords data that was used in the GFT project included information on the disease and medications that can be used in treating such diseases.

GFT is a novel Internet-based influenza surveillance system that uses search engine query data to estimate influenza activity and is available in near real time (Dugas et al., 2012). Studies were able to demonstrate the correlation between the data that was being collected in real time from the search query data and the number of clinic presentations across the United States (Pervaiz et al., 2012).

There are few studies that have used Google data across sub-Saharan Africa which are provided in the case studies below.

4.3.2.1 Google Search in Africa

Google Trends (GT) was also used to establish how people responded to the Ebola virus disease outbreak. Searches for keywords on Ebola between December 2013 and June 2015 showed that the three countries that were most impacted by that outbreak had concentrations of searches on the disease (Alicino et al., 2015). The researchers were able to use the search query data to identify the hotspot countries where the outbreak was most concentrated. However, when further analysis on country level data was conducted, the data did not provide reliable information on the hotspots within the countries. The researchers explained that these observations may have arisen due to inequity in knowledge distribution and digital divide within the countries.

In Madagascar, GT has been found to be useful in the investigation of geospatial distribution of plague. Researchers were able to demonstrate the correlation between the GT for the search of information on plague with surveillance data (Bragazzi & Mahroum, 2019). Okunoye was also able to use Google search data to show changing patterns and interests in HIV/AIDS information across Nigeria and South Africa (Okunoye, 2020). Earlier on, the search for information on AIDS was much higher than in 2020 when the search was done. However, there was a rise in the search for information on HIV. This might suggest that control activities through antiretroviral therapy which has reduced progression of AIDS have improved the chances of people surviving, and thus, people are less worried about the progression of the HIV infection to AIDS than earlier, around 2004–2006.

4.3.2.2 Bing Search in Africa

Abebe and colleagues used Bing search queries to understand the health information needs of people in sub-Saharan Africa (Abebe et al., 2019). They searched for information on HIV/AIDS, malaria and tuberculosis across the 54 African countries and were able to use the information obtained to make meaningful inferences on the health information needs and across the 54 countries in Africa. They proposed that researchers in health information can use such search query data to understand the health needs of people in their different countries which can influence various health and behaviour communication programmes that are targeted at improving the healthcare adoption of people in the region.

Search queries can certainly be useful for understanding current and future health needs and challenges of people across countries in the African region. For example, queries on specific diseases might point to an increase in concern on the disease and can prompt a quick intervention on how to mitigate the challenges arising from these. However, some of the knowledge that is generated from the search queries will need to be interpreted with caution due to inequity challenges across the region.

4.3.3 Using Social Media Data

Social media are defined as 'Internet-based channels that allow users to opportunistically interact and selectively self-present, either in real-time or asynchronously, with both broad and narrow audiences who derive value from user-generated content and the perception of interaction with others (Carr & Hayes, 2015)'. Due to its ease of use and rapid spread of information, the social media are seen as a veritable tool for information dissemination. In addition, because of its ubiquitous reach, the social media are seen as an important opportunity for reaching a wide geographic area or gathering data at minimal cost. Some important social media include Twitter, Facebook, MySpace Instagram and YouTube (Carr & Hayes, 2015). The adoption of social media across Africa has been growing at a tremendous rate (Poushter et al., 2018).

Much of the application of social media in the health sector has been geared towards health communication and behaviour change interventions (Korda & Itani, 2013; Moorhead et al., 2013). Research into the use of the social media has shown the potential of using this data source as a tool for predicting the future. Research conducted by Asur and Huberman showed that Twitter data could be used in predicting potential income prior to movie release (Asur & Huberman, 2010). They were able to use pre-release attention from the number of tweets, retweets, number of forwarded tweets and other user interaction to guess how well a movie would be received following its release.

There is increasing evidence on the potential for leveraging social media data for health research including digital disease surveillance. Digital disease surveillance is the use of Internet-based data in the explicit development or application of systems aimed at nowcasting or forecasting of disease incidence or prevalence (Aiello et al., 2020). This potential is not yet adequately being taken advantage of on the African continent. According to a systematic review conducted in 2015, of 33 papers that were identified to have investigated the use of digital data for disease surveillance, none was local to the African continent despite North America, Europe, Asia and South America having 48%, 24%, 15% and 3% of the literature reviewed, respectively (Charles-Smith et al., 2015). However, with the Ebola virus disease outbreak in West Africa and subsequent COVID-19 pandemic in 2019, Africa has seen an increase in the use of these data. There is a need for researchers on the continent to become more aware of the potential of the data from these global data mines and learn how to use them to address their research questions. This section will outline some of the opportunities in using different social media data. It will highlight how this has been done in some countries and the potential to expand them for other studies.

Social media platforms at registration collect basic socio-demographic information on the users of their platform. This information when combined with the content posted by users may be valuable research data to social scientists. In this section, we present how different social media channels have been used for research. We also identify how they have been used on the African continent and discuss the potential that can be achieved from lessons from beyond sub-Saharan Africa.

4.3.3.1 Twitter

Twitter is best described as a cross between blogging and instant messaging. It allows the user to send a short 280-character message (known as a tweet). It can be an important tool for disseminating research with a wider Internet community. However, asides being used to disseminate information and research, there is an increasing body of evidence that has used Twitter as the data source.

Twitter has been used for a variety of research which according to a systematic review categorized them into the following: politics, disaster analysis, sentiment analysis, disease surveillance and other topics (Karami et al., 2020). Another scoping review grouped the dimensions of use of Twitter for health research into six domains, namely, surveillance, event detection, pharmacovigilance, forecasting, disease tracking and geographic identification (Edo-Osagie et al., 2020). Just like Google search, Twitter has been used for monitoring disease outbreaks in different parts of the world. A study that investigated the outbreak of the Middle East respiratory syndrome coronavirus (MERS-CoV) in 2015 showed positive correlations between the trends on Twitter and the spread of the disease in the population (Shin et al., 2016).

Twitter has been used as one of the sources for disease surveillance on the African continent. The Nigeria Centre for Disease Control (NCDC)—Nigeria's National Public Health Institute—has developed a proprietary Internet crawling system called 'Tatafo', which generates unstructured event-based reports from 350 media sites (webs, newspapers, television, blogs/online media and social media) (Oyebanji et al., 2019). Tatafo is coined from a Yoruba word meaning gossip (Maxmen, 2019). It uses text mining, analysis and natural language processing to generate knowledge from intangible messages from the lay media and social media sites from across the country.

4.3.3.2 Facebook

Facebook is the largest and most popular social media platform across the world, boasting of almost three billion monthly users (Data Reportal, 2022). The platform makes it easy for users to connect and share messages, news and pictures with family and friends online. Facebook has many opportunities that can be leveraged for conducting research across SSA. Its very large population base makes Facebook a veritable recruitment platform for health research subjects. Its advertising tools enables users to target individuals based on certain social characteristics that the user wishes to target for their study (Kosinski et al., 2015). However, there are charges for using these advertising tools. Studies have shown that the cost per target in some cases could vary widely, with one systematic review noting the range between \$1.36 and \$110 per completing participant (Thornton et al., 2016).

Facebook can be useful for reaching hard-to-reach people who may be stigmatized in the real world. The relative anonymity of the Internet may provide an opportunity to specifically reach such individuals. The kind of information collected by Facebook such as sociodemographic characteristics, user-generated content, social network structure, user preference, and activities enables a large dimension of research on users.

Researchers have proposed Facebook for use as a tool, as a source of data and for context in ethnographic research (Baker, 2013). There have been several situations whereby people have published manifestos or posted coded messages on Facebook prior to either committing suicide or committing terrorist attacks. The study of some of these behaviours and early identification of those that may progress to carrying out these acts could have reduced the number of such cases that are recorded.

Researchers have been able to associate loneliness among Facebook users to be higher among those who reveal more personal information (Al-Saggaf, 2017). Using such information to identify lonely women can be used to target them with encouraging messages that can reduce their progression to depression.

Facebook however has equally been associated with various negative mental health outcomes including addiction, anxiety, depression, body image, alcohol use and other problems (Frost & Rickwood, 2017).

In Africa, Facebook has been used for recruitment of candidates for understanding technology-facilitated violence and abuse across the continent (Makinde et al., 2021). It has also been used for the coordination of adolescents for sexual and reproductive health education and research (Olamijuwon et al., 2021; Olamijuwon, 2021). In this study, the investigators used the Facebook platform to encourage young people to share information on sexual and reproductive health and monitored how others interacted with the information. It provided an important opportunity to learn how young people adapt to discussing uncomfortable topics virtually. This study provides an important opportunity for future interventions that target young people.

Shortcoming of data collection via Facebook is that respondents can easily abandon a data collection process with just a click of the button. This can be an issue when dropout rate becomes too high, thereby affecting the validity of the study or the randomization of the data. However, Facebook usage by a large population, ease of access to this population and cost-effective collection of widely dispersed data are valid reasons for Facebook to continue to be leveraged for recruitment of research subjects.

4.3.3.3 YouTube

YouTube is an online social media for sharing videos. YouTube has been predominantly used for sharing health-related educational materials. A systematic review conducted in 2014 on YouTube content found that there was an increasing use of YouTube for the dissemination of healthcare information (Madathil et al., 2015). The study also found that the information often found on many YouTube sites can be misleading. However, those contained on government sites could be very informative for information seekers.

Researchers have used YouTube to understand the perceptions of the population on their fear of dental procedures (Gao et al., 2013). In this study, researchers searched YouTube for any videos on dental fear and anxiety in children and used qualitative methods to extract information from these videos in order to understand the different dimensions of fear that children and adolescents face when they attend dental clinics. Through this study which used voluntarily provided videos of their experiences, the researchers were able to understand better the different dimensions and manifestations of fear that many people exhibit and their various coping mechanisms.

There are limited studies that have used YouTube as a data source in Africa. A recent study protocol highlights the interest of neurosurgeons to examine the usefulness of YouTube as a source of information for neurosurgical care (Ikwuegbuenyi et al., 2021). Just as reported in the dental study above, the researchers plan to examine the videos provided on the social media channel and assess their relevance to their topic of interest through qualitative and quantitative data extraction methods.

The opportunities to use YouTube for health education remain an important aspect that researchers have investigated and encouraged that healthcare providers and educators should explore more.

4.3.4 Mobile Phone Records

Mobile phone records can be an important source of tracking geographical movement of people. As of 2018, there were noted to be already more than five billion unique mobile phone subscribers across the world, and this number was noted to be growing significantly in LMICs (Jones et al., 2018).

Infrastructural gaps for wired lines made mobile phones the communication routes of choice across several countries in Africa. In a situation where most people in a country have a mobile or digital device that collects geographic information, this can be an important source of data to track mobility and potential for the movement of infectious agents across a country. There are recorded instances where call detail records (CDRs) have been used for research purposes which can be expanded and taken advantage of across Africa. However, this will require adequate deidentification and proper regulatory framework before such data can be used as it can be quite invasive for the mobile phone subscribers. CDRs are important as they do not require any active data collection effort. They are passively generated during use of the phones and are not smartphone bias. This means that ordinary non-smartphones can contribute to the data collected through this means, making the records inclusive of those that may not have smartphones or of lower socioeconomic status in the community.

The use of CDR alone may not be able to provide much information in health and medical research, and this important dataset will need to be linked to other data sources to be useful for health research. A systematic review on the use of CDR for health research found most studies that used CDR to have been conducted in LMICs, with many of them affiliated with research supported by Orange (a mobile network operator) in West Africa (Jones et al., 2018). This systematic review identified 46 publications based on research that had been conducted using CDR of which 42 were from Africa, including 13 from the Orange Data for Development Challenge on Mobile Phone Data focused on Ivory Coast. Research projects that have used mobile data for health include those for disease surveillance (across malaria, HIV, cholera, influenza, dengue fever, Ebola virus disease, schistosomiasis, rubella, meningitis and tuberculosis) and modelling population mobility after a disaster.

A study in Namibia has demonstrated how combining remote sensing data and mobile phone records can be used in predicting the movement of people from highly endemic areas to other areas with low endemicity. This information was then used for a targeted intervention for distributing insecticide-treated bed-nets to those that are likely to travel from high endemic areas to other areas in the country (Badiee et al., 2017). Targeting this category of subscribers helps in improving cost-efficiency for free distribution of such products to those likely to use it. This novel approach at using phone records for health risk control can be extended to other diseases.

The outbreak of the COVID-19 pandemic and the rapid spread of the disease across the world was an important milestone of unprecedented events in the current time which has led to lessons and developments which were previously unimagined. The need for tracking people who had been in contact led to the birth of various COVID-19 tracking applications that support tracking of individuals that have been in close proximity. In the event that one individual tests positive for COVID-19, the app automatically notifies anyone that has been in close proximity with the positive individual over a period to quarantine and get tested for COVID-19 based on their contact history. There were also efforts that utilized CDR and mobile phone records for this purpose at the peak of the pandemic. The potential of using CDR and mobile phone records for disease surveillance is rapidly evolving. However, its ability to be intrusive requires a robust regulatory framework before its use as unrestricted access and use can lead to abuse and human rights violation.

4.3.5 Data from Sensors

Various types of sensors are useful in health research. These can include remote sensors and wearable sensors. Remote sensing data can provide important information on changing environmental conditions that can influence the health of residents in an area. Remote sensing is the scanning of the Earth by satellite or high-flying aircraft in order to obtain information about it. Remote sensing provides an opportunity for gathering data on a large geographic area without needing to physically visit the location. It also enables the opportunity to collect multiple rounds of data on a particular area, thereby enabling the longitudinal study of an area over time.

The ability to link remotely sensed data with other health-related databases can provide an important data source that can be useful in determining how environmental factors influence diseases. A ten-year bibliometric analysis of health research leveraging remote sensing data revealed that malaria, dengue fever and schistosomiasis were the three most frequently investigated studies using remotely sensed data (Viana et al., 2017).

A study by researchers has outlined how remotely sensed data can be used by researchers to conduct various researches on nutrition and health of target population. The study highlighted the potential to link the demographic and health survey with normalized difference vegetation index (NDVI) to investigate the relationship between moisture and mortality in Africa (Brown et al., 2014). In the same study, researchers were also able to show how remotely sensed data linked with agricultural data may be used to predict nutritional outcomes in children.

Wearable- and non-wearable sensor-enabled medical devices are increasingly being available for healthcare providers and their clients. Remote monitoring of individual parameters has revolutionized some clinical disciplines such as cardiology and neurology, as it permits continuous monitoring of health parameters of individuals. The ability to aggregate these individual level data through technology companies can generate large datasets that can be mined to provide important information on disease distribution and risks across a geography of people.

The potential for using remotely collected data for health research is still evolving with the increasing availability and cheaper alternatives for these types of data which researchers need to be aware of in order to be able to take advantage of these data to answer real-world research questions.

One important challenge of using remotely sensed data is that it can be expensive to acquire more recent data. The data can also be quite heavy, thereby requiring hundreds of terabytes for the storage of moderately large images.

4.4 Potential Benefits of Using Non-traditional Data Sources

The non-traditional data sources are still emerging and have been described as the potential choice for addressing some of the challenges that NSOs face in finding appropriate data for measuring various health- and development-related goals. Their benefits are numerous and so are their challenges. We discuss some of the benefits of these non-traditional data sources.

4.4.1 Speed of Detection of Diseases

The use of non-traditional data sources for investigating some disease outbreaks has shown that they have a role to play in the prompt detection of potential disease outbreaks, thereby triggering interventions that can lead to a quick arrest of some of the deadly infectious disease outbreaks in the work. Evidence of this has been shown with the GFT. There are also cases where media analysis has helped with the direction of government attention to potential disease outbreaks in rural communities. These important data sources require adequate attention across Africa, especially in terms of capacity building and utilization. The Tatafo project by the Nigeria Centre for Disease Control can be a model for other countries on the continent to leverage.

4.4.2 Cost of Data Collection

The relative lower cost of reaching people across a wide geographic area using non-traditional data sources is one important benefit that cannot be easily ignored. This can facilitate prompt availability of data with a wide spread and also a large number of respondents. In some instances, such as using CDR, the data is collected routinely and passively and does not require any additional effort during collection. This makes large datasets available for mining which can be important for health research.

4.4.3 Geographic Spread

The most important feature of non-routine data sources is the ability for the data to be geographically linked. Mobile companies track the GPS location of the user, and this data can be important to disease investigation and other researches that can be conducted on the health system.

4.5 Challenges to Using Non-traditional Data Sources for Health Research

The rapid growth of digital epidemiology has outpaced regulatory frameworks especially around the big data that are used and has created new ethical challenges which require new perspectives and frameworks to tackle (Kostkova, 2018). We have grouped the challenges of the data into three categories: access, privacy concerns and quality of the data.

4.5.1 Access

Access to the data may be challenging as they are often generated by private institutions which may wish to see some financial benefits before the data can be utilized for research purposes. This might create a barrier to knowledge that can be obtained from these important datasets.

Asides this, the data are usually collected for other purposes and thus may require some additional data wrangling before the data is available to be used in the generation of national statistics or use for research. For example, the need to deidentify the data or merge with other important national datasets that can provide important knowledge might be needed before they can be leveraged. Expertise for these processes may not be readily available.

4.5.2 *Privacy Concerns*

Potential privacy violation and access to personal data while harvesting data from different sources is perhaps the largest barrier. Some of the non-routine datasets can be linked to an individual if too much information is provided, and this can present a potential breech of privacy. Thus, countries wishing to use such datasets must have a robust data protection framework that must be routinely audited in order not to let the good plans of utilizing such datasets for good turn into violation of rights.

4.5.3 *Quality of Data*

Quality of the data from citizen science projects can often be called to question. However, there has been documented instances where the quality of the data generated from these efforts has been comparable to those collected for the sole purpose of monitoring the projects which shows that they might be useful in specific instances. A project conducted by the World Bank and researchers from the University College London was able to demonstrate that crowdsourced geographic data could be of good quality for use by government systems (Haklay et al., 2018).

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Chapter 5
Mixed Research Methods for Buruli Ulcer Prevention in Southern Benin Using Geographic Health Surveys

Alexandra Boccarossa and Sébastien Fleuret

5.1 Introduction

Emerging diseases linked to environmental contamination are a major public health problem. One such disease is *Mycobacterium ulcerans* infection, or Buruli ulcer (BU), which has become the third most frequent mycobacterial infection after tuberculosis and leprosy (Dhungel et al., 2021). The rural zones of West and Central Africa, with their poor access to water treatment infrastructures and clean drinking water, are the regions most affected by this disease today (Simpson et al., 2021). This infection, caused by an environmental mycobacterium (*M. ulcerans*), causes vast skin ulcers and may lead to severe functional incapacity if the wounds are not treated in time (incidence of disability: 25%). This disease may, in rare cases, be fatal and has a major impact in terms of the stigmatisation, exclusion and poverty of those affected. It affects all age groups, but children under the age of 15 years account for almost half the cases declared worldwide (WHO, 2019). In Benin, women are more frequently affected than men in the adult population, but the sex ratio varies between regions (Vincent et al., 2014).

No interhuman transmission has ever been recorded. Instead, contamination occurs exclusively via an environmental reservoir (Garchitorena et al., 2014; Marsollier et al., 2002, 2007), linked to one or several aquatic ecosystems. Ecological

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studies have shown that an aquatic environment with a low oxygen content and temperatures of 29–33 °C (Merritt et al., 2010) is the ideal environment for *M. ulcerans* development. Other studies (Marion et al., 2011a; Marsollier et al., 2007; Wallace et al., 2017) have shown that the inoculation of skin tissues with the bacillus is required for disease development. In West and Central Africa, aquatic biting insects, including water bugs in particular (Portaels et al., 1999), which tend to develop and reproduce close to slow-moving watercourses or still bodies of water, are strongly suspected to be involved in transmission. The *M. ulcerans* bacterium has been detected in the salivary glands of these insects, and experimental transmission to mice has been demonstrated in the laboratory (Marion et al., 2010, 2014; Marsollier et al., 2007; Robbe-Saule et al., 2017). Studies performed in Australia suggest a different ecology of *M. ulcerans*, in which the bacterium is capable of colonising terrestrial mammals (Betts et al., 2020; O'Brien et al., 2019). The lesions are often localised on the lower limbs (60% of cases), and on the legs in particular, probably due to the mode of penetration of the bacillus into the body (Zingue et al., 2018). In this context, the principal risk factor for exposure to *M. ulcerans* identified to date in Benin is direct contact, of variable duration, with a slow-flowing or stagnant water source harbouring various aquatic organisms, probably leading to human contamination via bites, although this scenario does not exclude other possible modes of transmission (Boccarossa et al., 2020; Dhungel et al., 2021; Muleta et al., 2021).

Between the 1980s and 2006, the number of new cases of BU (between 5000 and 10,000 cases per year according to the WHO) and the number of humid tropical regions affected increased continually (Zingue et al., 2018; Degnonvi et al., 2019). This led to this disease being included in the list of 17 neglected tropical diseases targeted by the WHO. In Benin, the annual number of cases peaked in 2007, at a mean of 1200 reported cases for this year. Following a trend towards an increase in case numbers, 2217 cases were declared around the world in 2019, providing evidence of an unexplained progressive decrease in incidence in Africa (WHO, 2019). Conversely, a close examination of the principal epidemic foci in Africa identified major spatial disparities in the indicator of detection rates over the last 15 years (Fig. 5.2a). Taking the endemic Ouémé/Plateau region of Southeast Benin as an example, we find highly restricted zones in which detection rates remain high (between five and ten cases/year/borough) only a few kilometres away from zones presenting a marked decrease in incidence or even zones of non-endemicity (fewer than ten cases in ten years). Such exceptions can also be found at the scale of a village or quarter (Fig. 5.2b). Our team decided to use mixed methods of research to try to identify the anthropic and environmental factors accounting for this variation of incidence. This global research strategy is based on the principle that the dissemination of knowledge contributes to the adoption of prevention tools and health promotion in village communities.

This chapter aims to retrace the development of our research strategy, since 2016, up to the current research project, COPTER-UB (2022–2025). In the first year, we experimented with a new method: geographic health surveys. These surveys combine a classic case-control study with tools for data collection developed in the social sciences, associated with geolocalised and environmental analyses. Before presenting these surveys based on cross-comparisons of observations and our intermediate conclusions concerning the initial findings, we will explain the reasons for which a precise region of Southeast Benin was chosen as the study zone and the new methodologies and preliminary data available to us for the construction of this new project.

5.2 The Ouémé/Plateau Region: An "Experimental Space" for Investigating Variations in the Incidence of the Disease

Benin is one of the countries that has pioneered the fight against Buruli ulcer. Since 2005, almost all patients have been able to benefit from antibiotic treatment, either as outpatients or during hospitalisation, thanks to the establishment of four specialist centres in this country, in the towns of Pobé, Allada, Lalo and Zagnanado. Today, with early diagnosis, antibiotic treatment (Phillips et al., 2020) based on rifampicin and clarithromycin and appropriate lesion management, it is possible to control the infection and to prevent permanent sequelae, such as amputation and the disabling retraction of one or several limbs. However, this early management of lesions is often difficult in regions of endemicity in which the disease is rife, due to the inability of health structures to cover the rural zones they serve effectively and due to a preference of the local population for the traditional practices of their communities (such as self-care at home or consultations with practitioners of traditional medicine).

Our decision to perform our research in the Ouémé/Plateau region of Benin was based, first and foremost, on the high level of endemicity of Buruli ulcer in this geographic zone. This region is covered by the Centre for the Detection and Treatment of Leprosy and Buruli Ulcer (the CDTLUB) of Pobé, which still receives more than 50% of all cases detected in Benin. This hospital aims to strengthen early screening for skin ulcers in the most remote villages while improving the clinical diagnosis and therapeutic management of patients, with or without surgery. Since 2004, when the missions of the CDTLUB were launched, a research partnership has been established between this centre and the ATOMyCA team based in Angers, for work on the ecology of the bacterium and its mechanisms of transmission. A collaboration with the CNRS UMR 6590 team has also been established more recently, for the identification of territorial practices linked to the incidence of Buruli ulcer. This sharing of experiences and knowledge enables us to base our studies on a large cohort of Buruli ulcer patients. More than 2500 cases have been diagnosed, with biological confirmation by PCR, since 2006. The availability of key indicators, such as the age and sex of the patients, or the number of cases per year in more than 210 villages in the 5 municipalities of the study zone (Pobé, Adja-Ouéré, Bonou, Adjohoun and Dangbo), was also a major factor in our decision to perform investigations in this region (Fig. 5.1).

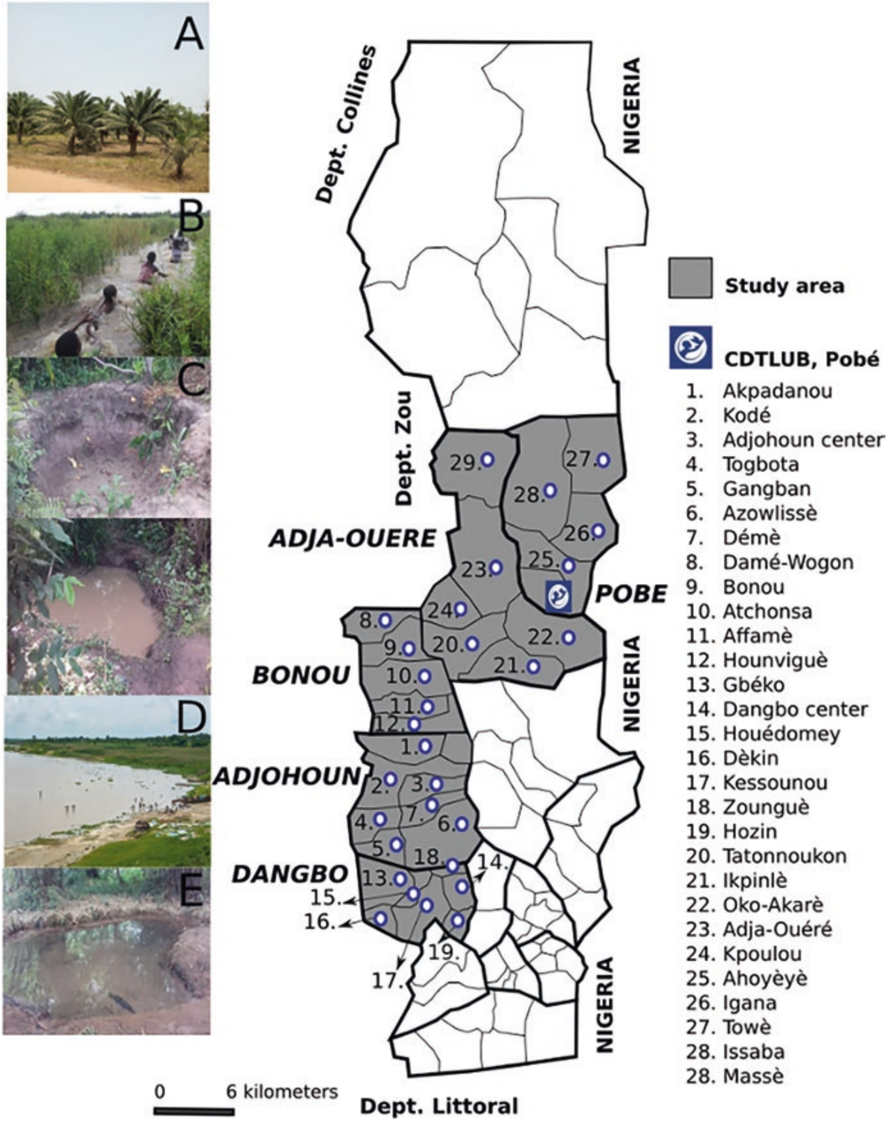

Fig. 5.1 Geographic location of the study zone: the Ouémé/Plateau region of Southeast Benin. (**a**) Oil palm plantations in the Plateau zone, (**b**) a seasonal body of water used by children for bathing, (**c**) seasonal water holes dug by humans, (**d**) the Ouémé River and (**e**) a managed spring in the Ouémé valley. (Source: *Cahier des villages et quartiers de ville du Département de l'Ouémé et du Plateau*, RGPH-4, 2016; Personal photographs taken by Boccarossa A. 2019–2022)

The study area can be split into two distinct zones: the Plateau and Ouémé zones. Oil palm plantations divide up the countryside in the two municipalities of Plateau (Pobé and Adja-Ouété) (Fig. 5.1a). Percolation levels are low in the soils of the villages of these municipalities, which are located far from the river and its principal tributaries. Many areas, including agricultural areas in particular, are flooded with rainwater runoff for several months of the year. When the level of flooding is sufficient to form a basin of water, children play (the school holidays coincide with this period), look for fish and bathe in these temporary bodies of water (Fig. 5.1b). Villagers in the Plateau zone generally get their water from bore holes or wells during the dry season. However, it is not unusual for them to shift these activities to natural seasonal water sources, ponds or water holes during the rainy season (Fig. 5.1c). These water sources were dug out by humans for the construction of dwellings or infrastructures for the village communities. They are of very different sizes, and the water they provide often originates from multiple closely spaced rain episodes. This context explains the rates of drilling work (for bore holes and wells) in the villages of Plateau being the highest in the study zone, with endemicity levels for Buruli ulcer that have remained stable for a decade (lower number of incident cases than the Ouémé zone). Buruli ulcer is endemic to 2 of the 44 villages of the Pobé municipality. These 2 villages, Eguelou and Onigbolo, recorded 18 and 23 cases of Buruli ulcer, respectively, between 2006 and 2020.

Unlike Plateau, the Ouémé zone is characterised by a large floodplain with a complex hydrographic system. The Ouémé river (Fig 5.1d) is used by the villagers, who have settled along its banks (village of Agonlin, Fig. 5.2b). This zone also contains tributaries and streams that join the river via various branches and springs located at the top of many of the drainage basins (Fig. 5.1e) that criss-cross the extremely shallow gradient of the fertile wetlands on which food crops predominate. The villages located close to this flooded and irrigated environment still have the largest numbers of Buruli ulcer cases. In the north of the Ouémé zone, two boroughs—Bonou and Damè Wogon—report between five and ten cases per year (Fig. 5.2a).

In this chapter, we associate the Plateau/Ouémé region with an "experimental space" for investigating these variations of incidence. If we focus on the endemic zone, it is frequently possible to find one or several endemic villages located close to non-endemic villages (Fig. 5.2b). For example, in the boroughs of Gangban and Togbota (Adjohoun municipality), the village of Gbada had 60 cases between 2006 and 2020, and Yokon had more than 25 cases over the same period. Each of these sites is located 4–6 kilometres away from villages with low detection rates over this period (Fingninkanme had only 5 recorded cases in 15 years) and non-endemic villages, such as Agonlin, along the banks of the river (Fig. 5.2b). The observation of isolated sites with discontinuous epidemic episodes is not unusual (Gbekandji, with 21 recorded cases). Our methodology is based on these spatial variations and exceptions.

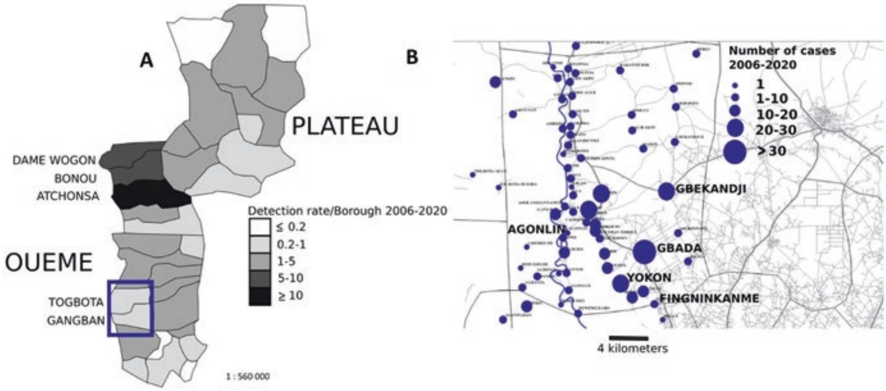

Fig. 5.2 Spatial disparities of incidence (by borough) and exceptions (villages) at the scale of the Ouémé/Plateau region. (Source: Surveillance data from the CTDLUB de Pobé; A. Boccarossa, 2022)

5.3 Preliminary Data and Methodological Advances

Over the last 15 years, many case-control studies have demonstrated that visiting natural and unprotected water sources for domestic activities (e.g. fetching water, washing oneself and doing the laundry) is reported more frequently by cases (Buruli ulcer, BU) than by controls (Aiga et al., 2004; Debacker et al., 2006; Kenu et al., 2014; Maman et al., 2018). Permanent surface water bodies located close to dwellings have, thus, become the reference spaces for studying risk factors for exposure to the disease. In parallel with these prospective studies, Benin launched a national anti-BU programme in 1997 (Johnson et al., 2008). One of the priority axes of this programme was the establishment of an epidemiological surveillance system. Since 2010, the surveillance data obtained have shown a progressive decrease in the number of new cases (Boccarossa et al., 2022; Degnonvi et al., 2019). However, inequalities in exposure to the disease are continuing to increase and translate spatially into marked differences in incidence between villages and, sometimes, even between quarters of villages within the same geographic area. The Ouémé/Plateau region in Southeast Benin is particularly strongly affected by these health inequalities. Our team therefore started from the initial hypothesis that these within-village fluctuations might be linked to the some water sources being more exposed than others to the bacterium, due to different organisations or different natural elements likely to influence the contamination of individuals either directly or indirectly. Differences in the modes of use of these resources were also suspected. Since 2016, we have performed coupled analyses of socioenvironmental data, shedding new light on these risk factors.

5.3.1 First Experimental Study (2016–2017): Relationship to the Establishment of Artificial Protected Water Sources

From 2005 onwards, studies (Wagner et al., 2008) showed that sites with daily access to hydraulic facilities (wells, bore holes or hand pumps), in both the dry and rainy seasons, had few, if any, cases of Buruli ulcer. This was the case in conurbations, which were better equipped with bore holes than remote rural areas, and in villages with no access to natural water sources in their immediate environment. In 2016–2017, a first experimental study (Degnonvi et al., 2019) aimed to investigate the possible correlation between this decrease in incidence and the progressive installation of hydraulic equipment in the villages along the banks of the river Ouémé close to semipermanent water courses or water sources (ponds and naturally formed water basins). This study was based on cross-comparisons of data from the CDTLUB of Pobé (epidemiological surveillance data) and the Ministry of Energy, Water and Mines of Benin (data on hydraulic installations in the area), followed by a case-control study (106 cases and 212 controls) in the community of Bonou (Ouémé).

This study showed that the progressive installation of hydraulic equipment in the villages had contributed to a decrease in the frequency of contact with natural water sources associated with a risk of exposure to BU (Degnonvi et al., 2019). By contrast, these protective actions alone were insufficient to account for the variations in BU incidence, because many domestic activities continued to be performed at natural unprotected water sources. In-depth interviews with the village communities and field observations provided us with an explanation for this situation (Boccarossa et al., 2020). Price was the first factor identified. Drinking water is often pumped or taken from a well, which is more expensive than using natural water sources, because of the higher quality of subterranean water, but many domestic activities are maintained in free surface waters. The decision to use a natural water source rather than water obtained with hydraulic equipment may also be correlated with site of residence according to the principle “you go to what is nearest”. The large amounts of water available at natural water sources also facilitate washing activities, particularly for laundry (Fig. 5.3a). In addition to the distance between dwellings and the hydraulic equipment, and the price of water, which may limit the use of water from certain sources for certain purposes, we also observed a diversity of local microconfigurations contributing to the maintenance of domestic activities at unprotected water sources. Firstly, water supplies were sometimes cut off following disputes within the village or with public authorities. Insufficient maintenance of many wells and bore holes also led to many breakdowns and the abandonment of certain wells and bore holes by the population concerned (Fig. 5.3b). Finally, when the depth of the water is sufficient for bathing activities, these natural water sources become the site of leisure activities for children (Fig. 5.3c) and a space for relaxation for adults. These bodies of water are also key sites for gatherings that are particularly appreciated by the local population (Fig. 5.3d).

Fig. 5.3 Local microconfigurations contributing to the maintenance of domestic and recreational activities in and around bodies of free surface water. (**a**) The large amount of water available facilitates washing activities, (**b**) definitive abandonment of a bore hole, (**c**) children bathing in the surface waters and (**d**) a site for social activities and meetings. (Source: Personal photographs taken by A. Boccarossa 2019–2021)

Using a bore hole or well was found to be associated with protection against BU in this study (Degnonvi et al., 2019), but the results also showed that the presence of hydraulic equipment in a village or quarter did not always guarantee the complete cessation of activities associated with free surface waters. The villagers continued to adopt mixed practices, using different water sources for different purposes (e.g. bore holes for drinking water and bodies of surface water for washing activities), thereby maintaining activities at risk of exposure to *M. ulcerans*. Our work then naturally focused on the precise identification and comparison of these water sources and the practices and behaviour of the local population with respect to water. This work was part of the GéANT programme, which obtained funding from the Pays de la Loire region (regional scientific issues) and the Raoul Follereau Foundation in 2017.

5.3.2 The GéANT Project (2017–2021): A Cross-Sectional Approach Focusing on Water Sources

In this project, we sought to acquire knowledge of the bodies of water most favourable to *M. ulcerans* and the activities associated with the highest risk of contracting the disease (detailed in Sect. 5.4.1). We also eliminated from our considerations all sites and behaviours considered "protective" (detailed in Sect. 5.4.3). For these reasons, the project was based on a three-principle transverse approach: observation of the principal water sources visited by village communities and the various activities practised at these sources, follow-up of cases and controls coming into contact with the water sources and a comparison of different attitudes with respect to environmental sampling, and a spatial analysis to characterise these spaces (Fig. 5.4).

Our preliminary data were obtained in a pilot study in health geography (Boccarossa et al., 2020) focusing on the hydrogeographic characteristics of the water sources frequented in village environments and the activities and attitudes of the inhabitants, at the scale of 37 villages in which BU was either endemic or non-endemic (non-endemic defined as fewer than ten cases over a period of ten years). Direct observation was at the heart of the research methodology. It involved walking around the perimeter of the village and identifying and characterising the principal water resources visited by the local population (Fig. 5.5). These field surveys, co-ordinated by the ESO team, provided us with quantitative and qualitative data for 198 water sources (167 water courses and 31 bodies of water) visited daily by

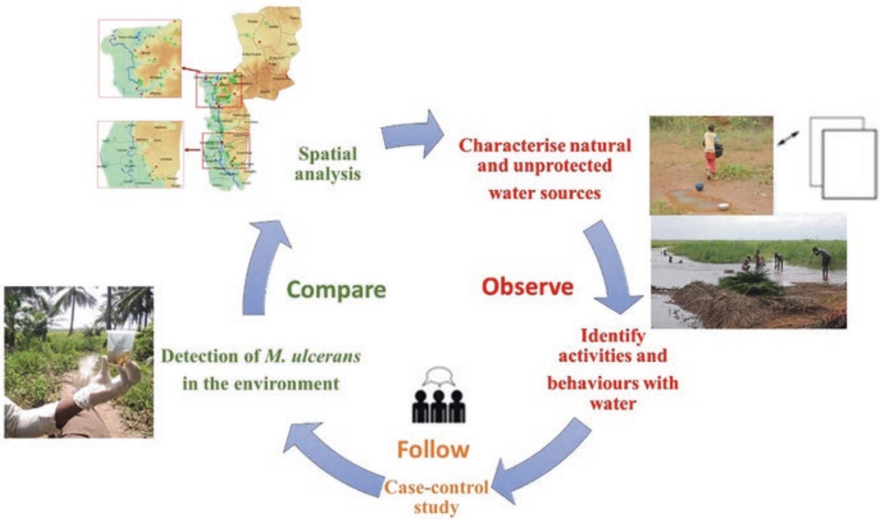

Fig. 5.4 Construction of the GéANT project around three principles: observation, follow-up and comparison. (Source: A. Boccarossa, 2022)

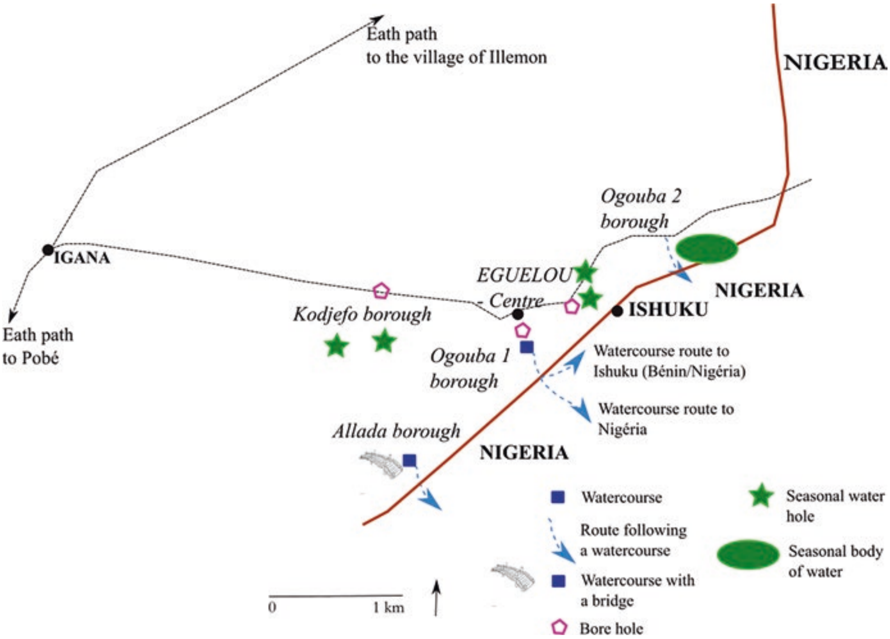

Fig. 5.5 Diagram summarising the natural water sources and hydraulic structures at Eguelou, an atypical village on the border with Nigeria. (Source: A. Boccarossa, 2022)

villagers. Not only did these prospective surveys make it possible to distinguish, at each site studied, traditional (river, tributary, water hole, etc.) and modern (bore holes, drinking fountains, cemented wells) water sources, but they also made it possible to identify clearly sites at which material had already been collected on the practices and behaviours of villages with respect to water. Observations were initially itinerant or "diffuse" (Gumuchian et al., 2000), with "fixed" or "posted" observations (Chapoulie, 2000) for nine natural water sources eventually completing the research strategy. These surveys took place in several steps: one or several periods of interaction with the population, observations of all the activities performed at different moments of the day and, finally, the recording of data with the assistance of printed and numbered observation grids. Finally, ten different activities involving contact with water were analysed. Collecting water (for drinking, cooking, washing-up or washing at home) and walking through watercourses on foot to reach cultivated fields or a neighbouring village were the two most frequently observed practices. In a sample of 1411 individuals observed, women aged 20–50 years (45%) and children of both sexes (27%) were the groups most frequently represented in these spaces.

The village of Eguelou, located in the borough of Igana, to the northeast of Pobé, on the border with Nigeria, had an incidence of BU of 5.2 for the 2006–2022 period. This incidence is relatively high for the zone. At this site, 19 cases of Buruli ulcer were reported, whereas most of the other villages in this borough are little affected or have never been affected by this disease. The village of Eguelou was, therefore, studied as an exception. During itinerant observations, we noted the installation of two functional bore holes in 2011 and a hydraulic structure that was not working. In the borough of Kodjefo, bore hole water was used by the entire population, for all domestic activities. By contrast, in the other three boroughs (Ogouba 1, Ogouba 2 and Allada), bore holes were used more occasionally and seasonally (when the natural water sources dried up). A first watercourse in Ogouba 1 constitutes the principal source of water in the village. The water flows slowly along a route regularly used by the population to get to the fields or to other villages on the Nigerian border. This water source dries up during a very short period, while the water table that feeds it is refilled. During this short period, the villages make use of bore holes or another watercourse located in Allada. At this water source, a wooden bridge has been built to enable villagers to cross from one bank to the other without having to enter the water. We also observed several water holes that had been dug in Ogouba 2 and Kodjefo. During periods of heavy rain, the water is stored and used for domestic activities and for the preparation of palm oil, but only rarely for drinking. These water sources may be considered a "back-up" in that they are only used for a few days or weeks of the year. Finally, a basin of water was subsequently discovered that is essentially visited by children for bathing and fishing activities. Repeated episodes of rain in the months of June and July create these new masses of water, the precise location of which may change over the course of seasons and years.

In the GéANT programme, an initial prospective (case-control) study provided us with data on the individual and social trajectories of 111 patients with BU confirmed by the CDTLUB of Pobé, who were then compared with a group of 222 controls. The dimensions covered by a questionnaire and an interview guide used from January 2018 to December 2020 broadly concerned personal characteristics, everyday habits and the modes and reasons for the use or non-use of free surface waters. A PhD student from Benin (thesis defended on December 3, 2021) visited the subjects at home for questioning. These epidemiological data were collected not only for statistical purposes but also as part of a territorialised environmental approach. More than 500 sets of GPS coordinates were recorded at the three types of site visited by the study subjects: (1) home, (2) work or school and (3) protected artificial water sources (wells and bore holes) and unprotected natural water sources (courses and bodies of water). These results enabled us to map the spatial and social practices of the patients, cases and controls in a geographic information system

(GIS) developed by the OIEs (Indian Ocean Spaces and Societies) laboratory of the University of Reunion Island. At the natural water sources identified by the patients, more than 1300 samples of aquatic plants, invertebrates and vertebrates and organic matter were collected from the environment, at more than 65 sites, and tested for *M. ulcerans*. The environmental samples were collected by a Beninese research assistant training at the HECOTES (Hygiene, Sanitation, Ecotoxicology, Environment and Health) laboratory at CIFRED (the Interfaculty Centre for Environmental Training and Research for Sustainable Development), at Abomey-Calavi University. Finally, the search for molecular signatures of *M. ulcerans* by quantitative PCR on tissue homogenates was performed by the ATOmycA team at the Nantes-Angers Centre for Cancerology and Immunology Research. This team had already developed the methodological know-how for this microbiological analysis in a previous ANR project (the EXTRA MU project), during which almost 30,000 PCR tests were performed on environmental samples over a period of 2 years (Marion et al., 2010, 2011b).

The results of this mixed-method research were recently published in *PLOS Glob Public Health* (Boccarossa et al., 2022). We showed that the frequentation of water sources is more risky if these resources are located in regularly flooded or irrigated wetlands, which can be grouped together under the umbrella term "low-lying" areas. The distribution of BU patients in the south of the country is delimited by the perimeter of two types of wetland (Fig. 5.6). On one side, there are lands with a shallow slope situated along or close to a large plain regularly flooded by the Ouémé in spate (type 1). On the other side, there are low-lying lands that are more circumscribed in space and characterised by shorter periods of flooding due to the accumulation of runoff water or the backing up of a downstream river or stream (type 2). The analysis of environmental data also demonstrated a greater abundance of *M. ulcerans* in the aquatic organisms collected in this low-lying area. Furthermore, our field observations revealed that the water sources present in these spaces were associated with a greater cumulative number of risk factors for transmission (slow flow rate, flow obstructed by an accumulation of sediment and plant material, greater number of biting insects in the water), particularly when the water levels of the river subside (in October–November). Finally, these observational data revealed that the behaviours and territorial practices taking place in these low-lying areas are far from limited to domestic activities. As a means of diversifying their income and supplying the markets of the towns and their surrounding areas with fresh produce, the villagers have developed rice and maize production and market gardening activities (Hounsou et al., 2020; Iwikotan et al., 2016). Since the 1980s, runoff and irrigation networks have been traced out, to improve the use of the damp and fertile low-lying areas (Abou et al., 2018). These localised practices in the low-lying areas, which have increasingly been shown to be associated with risk factors for exposure in recent case-control studies (Dhungel et al., 2021; Muleta et al., 2021), remain little known and have not yet been systematically analysed. In future projects, we will therefore need to broaden our view, expanding from studies of water source use (GéANT project) to studies of all spaces favourable to vectors of the disease. The DAILYRISK-MU project, funded by *Fondation de France*, aimed to explore a new

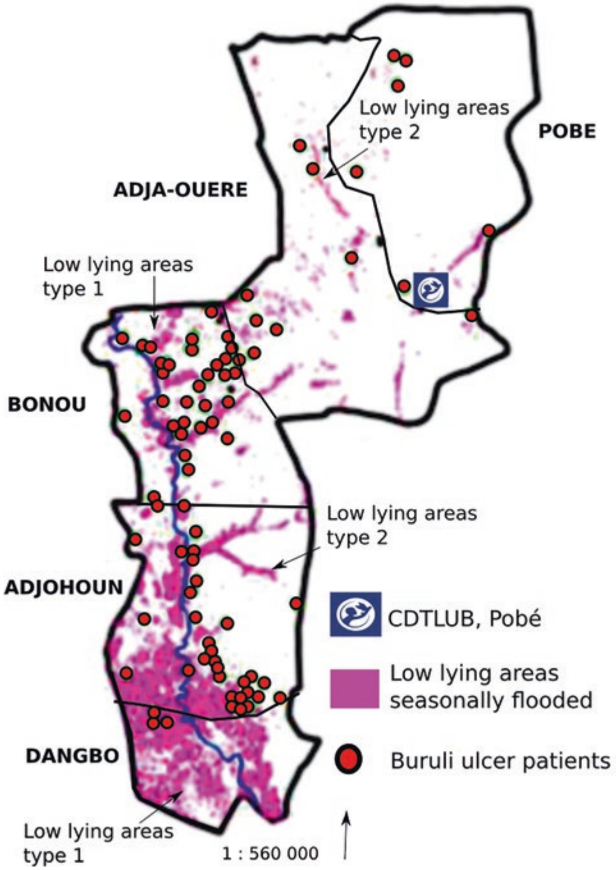

Fig. 5.6 Distribution of BU cases in the zones of Plateau and Ouémé in South Benin in the 2018–2020 period (Source: GéANT project data, 2022)

research protocol following this rationale—geographic health surveys—over the course of a year.

5.4 Geographic Health Surveys: Shifting Focus to a Search for All Spaces Favourable to Vectors of the Disease

The aim of these surveys is to continue to follow all new patients over the 2022–2024 period, according to the integrative approach developed in the GéANT programme (Fig. 5.4). However, the acquisition of territorial and environmental data has been expanded to all living spaces (home, work, school, water sources, bathing areas, routes taken to get from one place to another, cultivated fields, etc.). As in the GéANT study, the patients recruited for this study are defined as people who have developed one or several “Buruli ulcers” detected by screening and confirmed by PCR. The inclusion of cases contracting the disease in regions other than those covered by the CDTLUB of Pobé is avoided by including only patients residing in the geographic area of the study zone at the time of diagnosis (Fig. 5.1). The study area encompasses the villages belonging to two municipalities in the Plateau zone (Pobé and Adja-Ouéré) and three municipalities in the Ouémé zone (Bonou, Adjohoun and Dangbo). All villagers in these two zones have similar access to care, and the same preventive strategies have been deployed to combat this disease (in terms of sensitisation, active screening, treatment and follow-up campaigns). The basic principle of a case-control study is also conserved in this study, with the selection of two controls from the community for each patient recruited, matched for site of residence, age, sex and profession (for adult cases). Based on our initial study, we estimate that the geographic health surveys should be based on 150 cases and 300 controls (given a mean of 50 new cases/year).

The GéANT programme gave rise to a prospective case-control study and made it possible to determine the attitudes of the villagers and the activities associated with the greatest risk of exposure to *M. ulcerans* through fixed and itinerant observations (Figs. 5.4 and 5.5). We are currently extending this work, by combining these methods to determine which of the patients, cases or controls are most prone to practices exposing them to infection. The methodology of this new project, thus, follows the same process of iterative engagement, involving a long interview with cases and controls at their home (with an interview guide and a questionnaire) and then accompanied field visits combining the taking of GPS coordinates with environmental sampling if risk factors for transmission are found at the site (detailed in Sect. 5.3.2). The novelty of this project also lies in the implementation of surveys specifically adapted for children aged 8–14 years, based on several tools described below.

5.4.1 Long Interviews at Home: Collection of Qualitative and Quantitative Data on Lifestyle and Habits with Respect to Water

We retained the questionnaire and interview guide developed in the GéANT study, to ensure compatibility between our future data and those previously collected. The current study is novel in the addition of questions on factors explaining disease and the local perception of these factors among patients and controls. The objective is to determine whether the perception of the disease, and, thus, the adoption of preventive attitudes on the one hand, or recourse to care on the other, varies according to the site and the life context of the people interviewed. Finally, we are extending the GéANT programme by adding items relating to five types of behaviour specifically associated with a risk of transmission to the interview guide. These types of behaviour have been identified in our results or in published studies but have rarely been analysed with a systemic approach (Fig. 5.7): (a) children’s bathing activities, (b)

Fig. 5.7 Five types of behaviour specifically at risk identified in Southeast Benin. (**a**) Children bathing, (**b**) washing activities at "seasonal sites" and at water sources submerged by local flooding, (**c**) hydroagricultural work in the low-lying areas, (**d**) walking through watercourses to get to a field or neighbouring village and (**e**) the collection of aquatic forage plants to feed domestic animals. (Source: personal photographs taken by A. Boccarossa 2019–2022)

washing activities at "seasonal sites" and water sources submerged by local flooding, (c) hydroagricultural practices in the low-lying lands, (d) walking through watercourse to get to cultivated fields or to a neighbouring village and (e) the collection of aquatic forage plants to feed domestic animals.

5.4.2 Guided Tours: Collection of Geolocalised and Environmental Data

With a view to characterising the activities and spaces at risk of exposure to *M. ulcerans* as well as possible, the long interview at home was followed by a guided tour. This tour was scheduled to take place either directly after the interview or at another

In the preparatory phase of the project, the fifth of these elements—"collecting aquatic forage plants to feed domestic animals"—was not specifically targeted. In 2011, a case-control study in the region endemic for BU of Bankim in Cameroon revealed an association between the presence of domestic animals, such as pigs, goats and chickens, in domestic living spaces and an environmental risk of infection (Landier et al., 2011). In our study zone, domestic animals also live in close contact with the local population, in enclosures or freely roaming, but interventions between humans and animals were not previously suspected to play a role in BU. Nevertheless, our investigations in the municipality of Adjohoun (Ouémé) in November 2021 enabled us, for the first time, to identify a type of risky behaviour linked to animal husbandry: daily searches for herbaceous plants in the low-lying lands for use as animal feed, a form of feed particularly appreciated by sheep. *Ipomoea aquatica Forssk*, also known as kangkong or water spinach, is a semiaquatic plant that grows specifically in marshes and wetlands. The plants of this species are collected by hand, without the use of protective clothing (e.g. boots or long clothes). Based on this observation, the bacillus could be transmitted during this specific practice, if the aquatic plants that proliferate in the Ouémé valley are considered to be a possible reservoir of *M. ulcerans* (Marsollier et al., 2007). DNA from *M. ulcerans* has already been detected in insects and molluscs sampled from the roots of aquatic plants in Southeast Benin (Portaels et al., 1999) but also in the stems and leaves of these plants. We have added a section to the questionnaire dealing specifically with this behaviour, to explore the role of this practice in transmission mechanisms.

time in the week. This method is inspired by work performed by the Cresson team at the University of Grenoble (Lenel, 2014) and the mobile research method developed in the (Extra)Ordinary Lives project (Ross et al., 2009). It involves planning a tour of the everyday living spaces of the people interviewed, on foot, in the spirit of a guided tour, with the person guiding the tour providing comments, during the walk and on site, of their practices and attitudes with respect to the sites evoked in the interview guide. In this study, the patients/controls receive some advice at the start. They are asked to plan a route including all the sites at which direct contact with water occurs together with permanent or seasonal wetlands. As in GéANT, GPS coordinates are recorded for all the sites visited, with a Garmin Etrex 10 device, and environmental samples are collected. Aquatic invertebrates and vertebrates (insects, spiders, molluscs, shrimps, etc.) are collected at all the "points of contact with the aquatic environment" visited by the cases and controls studied (in years 1 and 2 of the project). Samples are collected with a net with a mesh size of less than 1 mm (Fig. 5.8a). Water bugs are separated from the other invertebrates (Fig. 5.8b) and samples of aquatic plants (Fig. 5.8c) to complete the sampling procedure.

Fig. 5.8 Collection of environmental samples from the aquatic sites visited by the study subjects. (**a**) Equipment required for the collection of insects and plants, (**b**) water bugs sampled in the field, (**c**) aquatic plants sampled in the field and (**d**) environmental sampling session at a village endemic for BU. (Personal photographs taken by A. Boccarossa, 2019)

For each sample collected, a form is completed, providing information about the topographic and hydraulic characteristics of each point of contact with the aquatic environment. The individuals present during sampling (Fig. 5.8d) are also asked about water management and associated behaviours with respect to water. Rainfall patterns in this zone are marked by a four-month period of flooding (from July to November) that modifies the interactions of villagers with aquatic resources and the ways in which they can use water. For example, children can bathe and washing activities can take place in temporarily flooded zones that are dry during the rest of the year. Seasonal dynamics have been integrated into our analyses, with scheduled sampling at points of contact with the aquatic environment at this precise time in the year or during two periods of the year (once in the dry season and once in the rainy season). Based on our experience in the field and the method used, we estimate that we will need to analyse about 300 sites during the study period (a mean of 100 sites sampled per year).

5.4.3 Survey Tools Adapted for Use with Children Aged 8–14 Years

Over the 2018–2020 period, almost 52% of the patients diagnosed and treated at the CDTLUB of Pobé were schoolchildren, high-school students or adolescents not attending school (Degnonvi et al., 2019). Based on this information, we considered it essential, in this new study, to identify more precisely the behaviours, representations and opinions of this group of young people. The difficulties experienced in the questioning of children and adolescents with classical survey methods (questionnaires and interviews) constitute a subject increasingly frequently dealt with in articles and seminar reports in the domains of sociology (Camus et al., 2020), anthropology and social sciences (Danic et al., 2006; Potin, 2012; Robin et al., 2017) and education science (Euillet, 2017). The research objectives and terrains dealt with in these previous studies were all different, but all studies on childhood cultures and the world of adolescence agree on one point: the need to adapt the data collection methods to these young individuals or to "create" an appropriate method. On reading the articles corresponding to the principal case-control studies performed to date on our subject in Africa (Aiga et al., 2004, Debacker et al., 2006, Kenu et al., 2014, Landier et al., 2011, Maman et al., 2018), we noted that exactly the same data collection methods had been used for the children as for adults. This approach has two limitations: a methodological limitation relating to the risk of the child or adolescent not understanding or misunderstanding the questions and an ethical limitation linked to the well-being of these youngsters, who, in a classic interview based on questions and responses, may have the feeling that they are seen and considered to be different from the other youngsters living in their district (Potin, 2012). Our field experience also suggested that some children are very prudent and circumspect when asked about the disease at the start of the interview and that they have difficulty expressing themselves about their activities and the sites they visit if interviewed in the presence of their parents. For this reason, we felt that the implementation of survey methods specifically adapted for children and adolescents was particularly important in this project.

For this purpose, we decided to use fun supports for the collection of data. After carefully studying published articles on the subject, we chose supports that evoked the spaces of everyday life, and the different types of behaviour with water were presented as drawings on cards (Fig. 5.9). This new approach was based on the WASH programme, which had already been tested in schools, notably in Benin, and which made use of drawings to raise the awareness of children concerning hygiene and sanitation (Peal et al., 2011). For our study, 24 cards were developed. The regular or seasonal activities depicted on these cards are based largely on the results of the GéANT case-control study and our observational data (see Sect. 5.3). The card collection has an amusing and stimulating graphical environment designed in partnership with a Beninese designer (Fabel Art Pobé).

In addition to being more agreeable for the children, this new survey system aims to improve the quality of the results obtained. The children are questioned directly,

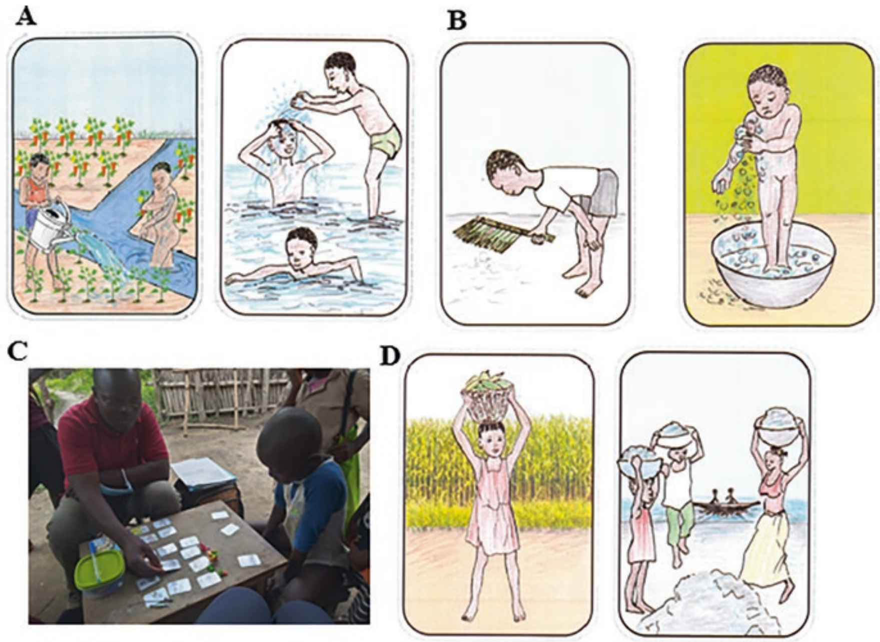

Fig. 5.9 Several examples of the drawings on cards used in surveys with children. (**a**) Activities associated with a risk of transmission, (**b**) "protective" activities, (**c**) testing of the protocol with a child with BU diagnosed in 2020 and (**d**) weekend and holiday activities. (Source: COPTER UB, 2022)

in the first person, without interference from their parents. The children are asked to choose, from among the cards presented to them, those best corresponding to their living spaces and the activities they perform during a typical weekday: when they get up in the morning, at school, what they do when they come home from school and before going to bed (Fig. 5.9c). Some of these cards (Fig. 5.9a) represent specific risky practices (e.g. playing in the water or washing in irrigation channels), whereas others (Fig. 5.9b) show practices that are considered to be "protective" (playing with a ball, washing clothes or oneself in the courtyard of the house). Each set of drawings selected by a child case is photographed by the investigator and then compared with equivalent photographs for the corresponding two cases. The children are also asked to select two other series of cards corresponding to a typical day during the weekend and during the school holidays (Fig. 5.9d). During these two periods, many children help their parents with work in the fields, have jobs in the sand quarries, amuse themselves in the water and go fishing. The preferred times for interviewing children are the school holidays and the hours of the day during which the children are free (after school). As for adults, the exchanges are recorded and retranscribed at the end of the fieldwork. Finally, the children are also given the possibility of extending the interview with a guided tour. They can be replaced by their parents or guardians for this tour if they do not wish to be seen at the sites they regularly visit.

5.5 The Lessons Learned Mid-study

Health geographic surveys were tested with 40 patients and 80 controls (between November 2021 and July 2022), in the framework of the DAILYRISK-MU project (2021–2023). Midway through the study, we have learned several lessons through the use of this new research strategy based on the cross-comparison of observations.

Firstly, this new research protocol provided data complementary to the classical data on new spaces that had never before been studied as sites of possible contamination or that had been little documented (bathing areas, paths through water, fields cultivated in flooded areas, etc.). The information about the identity and lifestyles of the cases and controls has been enriched in this study, together with information about activities outside domestic spaces. An analysis of the new data provides more detailed knowledge of the habits of the subject, which should make it possible (in year 3 of the project) to establish typical behaviour profiles related to the risk of contamination (and, subsequently, the targeting of prevention measures for these profiles). The guided tour method also proved useful in this first phase of the project. The field visits progressively led those questioned to mention sites or activities that they would not spontaneously have thought of during interviews at home. This method also made it possible to place the initial description of territorial practices and behaviours with respect to water within an environmental context. Finally, new activities associated with a risk of transmission were discovered through these field visits (collection of forage plants from the low-lying areas for use as animal feed, washing activities (washing the feet or the clothes worn in the field) in irrigation channels, etc.) and were progressively integrated into the definitive version of the questionnaire. The collection of these territorial and environmental data will be continued in the COPTER-UB (2022–2025) project funded by the ANR (the National Research Agency), to reach our objective of 150 cases and 300 controls investigated. As a means of determining the extent to which this global research method can be transposed to other endemic areas, we will also test geographic health surveys on patients diagnosed and treated at the hospital in Lalo (15 cases per year, on average, since 2019), in October 2022. This centre is located in Southeast Benin, about 140 kilometres from Pobé.

The collection of numerous series of environmental samples since the GéANT project has enabled us to identify visually the aquatic sites at which we expect to find *M. ulcerans* and those that are probably safe. Rather than searching for the presence of the bacillus in the environment, by collecting very large numbers of samples, as in the past, we can now work on bioindicators of exposure. This profoundly changes the way in which we approach fieldwork and the manner in which we transmit knowledge to the local population. The sites not considered at risk include, for example, (1) springs and streams for which plant cover had been conscientiously removed from the contours, (2) water sources that have a good flow rate and are never contaminated with salt water from the low-lying areas and (3) protected springs, with a horizontal trench dug by the villagers over several metres to identify the source of the spring, which has been concreted over. Our experience of

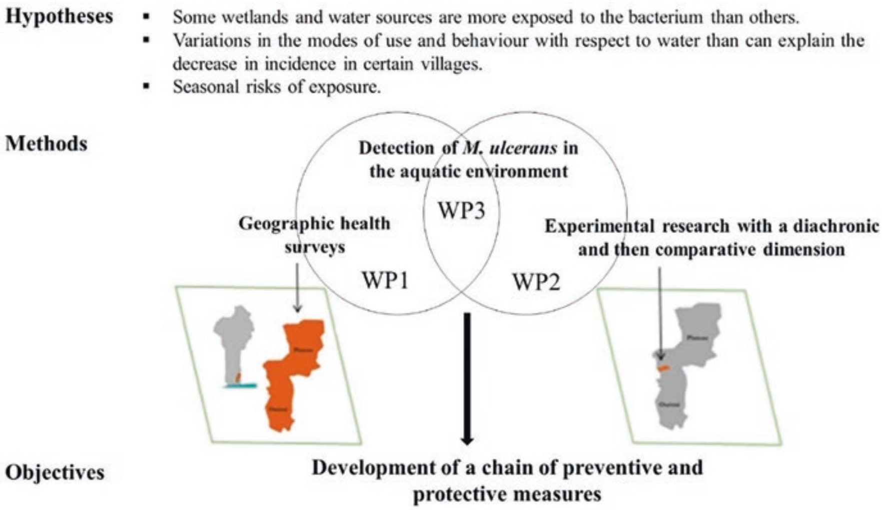

Fig. 5.10 Structure of the COPTER-UB project, indicating the links between WP1, WP2 and WP3. (Source: A. Boccarossa, 2021)

environmental follow-up in the field has also shown that the collection of invertebrates and vertebrates in the environment often triggers a reaction among local actors, with discussion or even participation (Fig. 5.8d). To date, control measures based on the collection of environmental samples have been designed to determine whether or not *M. ulcerans* is present in the areas of contact with the aquatic environment frequented by patients. From now onwards, we also aim for environmental monitoring to become an instrument of prevention capable of sending local actors signals concerning the best way to act. For this, various types of knowledge, including environmental data, have been integrated into a new research action programme (Fig. 5.10) that will be implemented in parallel with the geographic health surveys.

We plan to decrease the risks of exposure to *M. ulcerans* by adopting the principle that preventive and protective actions must be based on the experiences of local communities, their traditional organisation of spaces and their local knowledge. For this reason, the methodology has evolved in the COPTER-UB project, through experimental research with a diachronic and then a comparative dimension. This second research axis aims to demonstrate differences in the dynamics of exposure to *M. ulcerans* (based on a detailed territorial diagnosis) and to reflect on protective solutions based on the participatory learning tools of the ComMod approach (Etienne, 2010; Fauvelle et al., 2012). For this purpose, we will organise discussion groups (in four test villages), to disseminate our results and to develop with local communities (at the end of the project) what we refer to as "adaptation scenarios". Today, we imagine that these solutions will operate at the levels of individual behaviour, health education targeting both typical profiles (e.g. fishermen/farmers) and specific spaces, with the community surveillance of cases (through active screening) and the organisation of community health actions (treatment accessibility) and, finally, through changes in the layout and organisation of the territory (e.g. access to clean water). This perspective also meets the UN Sustainable Development Goal 3.d, whose aim is to strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks.

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Part II
Environment, Health and Disease

Chapter 6
Spatial Analysis of Antiretroviral Therapy Attrition Among Adults in Zimbabwe HIV: Geo-Additive Bayesian Survival Models

Zvifadzo Matsena Zingoni, Tobias F. Chirwa, Jim Todd, and Eustasius Musenge

6.1 Introduction

Human Immunodeficiency Virus (HIV) is one of the leading causes of infections globally regardless of the success of antiretroviral therapy (ART). HIV remains one of the major global challenges since 38.4 million [33.9 million–43.8 million] of the world's population were living with HIV in 2021 worldwide (UNAIDS, 2020). However, the heavily affected region is sub-Saharan Africa (SSA) as it accounts for 53.6% [20.6 million] of global HIV infections (UNAIDS, 2020). In 2021, the adult HIV prevalence in Zimbabwe was estimated at 11.6% (10.2–12.7%), and 1.3 million [1.2 million – 1.4 million] people were living with HIV (PLWHIV) in the same year (UNAIDS, 2020).

Globally, 74.7% [28.7 million] of those PLWHIV were accessing ART in 2021 (UNAIDS, 2020). In the SSA region, among those PLWHIV, 78.6% [16.2 million]

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were accessing ART in 2021, while in Zimbabwe the ART coverage was estimated at 91 (84–98)% [1.1 million] in the same year (UNAIDS, 2020). The initial regimen for an ART naïve patient is the first-line ART, a combination of two nucleosides reverse transcriptase inhibitors (NRTI): The first drug can be Zidovudine (AZT), Tenofovir (TDF) (the most common) or Stavudine (D4T) and the second drug is mainly Lamivudine (3TC); and one non-NRTI which can either be Nevirapine (NVP) or Efavirenz (EFV). ART, as comprehensive care and support package for HIV-infected people, has been shown to have remarkable clinical benefits among PLWHIV such as slowing HIV disease progression (Geng et al., 2012), preserving health by prolonging survival outcomes (Kitahata et al., 2009); hence, it reduces mortality, improves the quality of life by minimising severe HIV-related opportunistic infections (Cohen et al., 2011), hinders immune deterioration and improves viral load suppression (Havlir et al., 2020).

The World Health Organisation (WHO) ART initiation guidelines have been changing over the years as informed by the benefits of ART. In resource-limited settings like Zimbabwe, ART was primarily initiated for all individuals with cluster differentiation 4 (CD4) cell counts of ≤200 cells/mm^3 or with WHO clinical stages III/IV (Tlhajoane et al., 2018). In 2010 and 2013, the CD4 threshold for ART initiation was increased to ≤350 cells/mm^3 and ≤500 cells/mm^3, respectively (Tlhajoane et al., 2018). In 2015, the "treat all" recommendation came into effect, this means everyone who tests HIV positive be immediately initiated on ART regardless of their CD4 cell counts or clinical stages to achieve viral suppression (World Health Organization, 2016). To effectively drive the implementation of the "treat all" guidelines, the Joint United Nations Programme on HIV/AIDS (UNAIDS) launched the 90-90-90 fast track targets for 2020 whereby 90% of those who are HIV positive know their status, 90% of those who know their status have access to ART and 90% of those on ART are virally suppressed (UNAIDS, 2014). By the end of 2020, the global estimates for the fast-track targets were missed and the achievements were 81-67-59 (World Health Organisation, 2020). Zimbabwe made some remarkable progress towards the 90-90-90 UNAIDS targets, but the first target was missed and the achievements were set at 83-97-91 (ICAP, 2020). Currently, most countries are striving to meet the current 95-95-95 targets that aim at reducing HIV transition to zero.

Although the ART coverage has increased significantly and the benefits of the HIV "treat all" strategy are starting to be felt across the globe, the impact of these strides depends on how well the PLWHIV adhere to treatment (Bam et al., 2015) and how continuously do patient engage in HIV care (Bock et al., 2019). One of the legitimate strong threats to full optimisation of the HIV "treat all" strategy is ART attrition (non-retention in care due to loss to follow-up (LTFU), withdrawal, dropouts and death). ART attrition indicator measures the progress towards promoting retention of ART and mitigating loss in the HIV treatment cascade (Makurumidze et al., 2020b), which includes HIV diagnosis, linkage to care, engagement in care, ART initiation and adherence, and viral suppression, and this has threatened the long-term success of national HIV programmes, particularly the ART scale-up (Kay et al., 2016). However, the upsurge of ART attrition is more likely during the HIV "treat all" strategy as mostly "well" HIV-positive individuals are initiated on ART.

Several studies have reported high rates of ART attrition and its obscuring effects on getting the optimum benefits of the HIV "treat all" strategy that subsequently triggers ART drug. A study done in Nigeria reported an ART attrition rate of 34% in the "treat all" arm (Stafford et al., 2019), while another recent study in Zimbabwe reported an attrition rate of 20% among PLWHIV using routinely collected patient-level data reported 25.6% attrition rate in a 5-year follow-up cohort (Makurumidze et al., 2020b). Individuals who initiate ART following the "treat all" guidelines are more prone to experience ART attrition as they are mostly "well" individuals. Some of these individuals have high baseline CD4 cell counts and relatively low viral loads.

The correlates of ART attrition (LTFU and mortality) include low CD4 cell counts, high viral load, being classified in WHO clinical stage III/IV and those with tuberculosis (Matsena Zingoni et al., 2020). The age of an individual plays a crucial role in predicting ART attrition since adolescents and young adults have been found to have an increased risk of ART attrition (LTFU) compared to adults, and this has been attributed to the lack of psychosocial support in this group. Males also are part of the underserved sub-population in HIV programmes as they have been in the blind spot of the response to HIV for decades (UNAIDS, 2017). Health facility factors suggested to be associated with ART attrition include distance to the health facility, level of health facility, location of the health facility (rural or urban) and the implementation of the decentralisation of ART services (Decroo et al., 2017). Recent studies have looked at the risk of ART attrition and its correlates at the national level (Makurumidze et al., 2020a) and at provincial levels (Tlhajoane et al., 2021) and in clinical trials (Stafford et al., 2019) have compared ART attrition before and after the "treat all" recommendation (Makurumidze et al., 2020b; Matsena Zingoni et al., 2020; Tlhajoane et al., 2021), but the spatial heterogeneity effects have been neglected.

Since several public health problems tend to exhibit spatial dependency (spatial heterogeneity, spatial variation, spatial autocorrelation), utilising spatial modelling is important. The spatial analysis technique has been used significantly in public health research, for instance, in the maternal and child health (MCH) book (Kandala & Ghilagaber, 2014). The statistical rigour explained in this book on MCH can be applied to HIV given its public health significance. In recent years, spatial analysis has been extended to answer HIV research due to the availability of geo-referenced data, including SSA. Several studies have looked at the spatial heterogeneity of HIV prevalence in South Africa (Ayalew et al., 2021) and Zimbabwe (Schaefer et al., 2020); new HIV infections in Uganda (Boyda et al., 2019); uptake of HIV services (Schaefer et al., 2020); HIV service implementation like estimating the effect of distance to HIV services on health outcomes; and planning and evaluating HIV services provision (Boyda et al., 2019). However, the focus on ART outcomes like attrition and adherence in relation to spatial heterogeneity has not been substantially considered, maybe due to data sparsity. Therefore, with the high increase in ART attrition rates being reported in Zimbabwe during the HIV "treat all" strategy (Tlhajoane et al., 2021), there is a need to look at the spatial heterogeneity of ART attrition rates in Zimbabwe before the implementation of the HIV "treat all" strategy and identify the associated hot spots.

In this era of decentralisation of governance and service provision to curb HIV, designing effective HIV intervention programmes and monitoring strategies at local administrative levels like districts requires reliable estimates of area variation in ART attrition. The spatial analysis will benefit the ART programme by generating maps to visualise the distribution of ART attrition rates in Zimbabwe and identify critical regions that exhibit high spatial dependency (Martínez et al., 2022). The communities that are at high risk of ART attrition will be identified, and underlying socioeconomic factors associated with ART attrition variations can also be identified (Martínez et al., 2022). To the policy-makers, the spatial analysis will help understand evolving health threats like ART attrition and reveals patterns that are not apparent in non-spatial models. Moreover, the spatial analysis may allow for a more efficient allocation of resources as it informs decision-making (Kim et al., 2016), and targeted interventions that minimise ART attrition can be implemented in many resource-limited African settings for the greater benefit of the population (Kim et al., 2016).

Studies that have looked at ART attrition utilised conventional statistical methods, which assume that the ART attrition risks are uniform within a country which is not always true. Failure to account for spatial dimension in the data leads to an overestimation or underestimation of the precision in predicting the risk. To our knowledge, this is the first study to implement geo-additive modelling on the time to occurrence of ART attrition in Zimbabwe. This study complements existing research that has looked at the spatio-temporal patterns of LTFU in Zimbabwe (Matsena Zingoni et al., 2022), and the intended contribution of this work to literature is to simultaneously account for the spatial and non-linear effects on ART attrition relationships that are overlooked by conventional time-to-event methods. This study utilises a geo-additive survival model from the Bayesian perspective (Adebayo & Fahrmeir, 2005) using routinely collected patient-level time-to-event data at the district level. Appropriate priors for the spatial and non-linear effects were utilised, and the model estimation computation was done through the Markov Chain Monte Carlo (MCMC) technique.

6.2 Methods

6.2.1 Study Design

Secondary data analysis of routinely collected longitudinal HIV monitoring data compiled through the electronic patient management system (ePMS) was conducted. The data were a sub-sample of all PLWHIV in Zimbabwe; however, it was representative enough to describe the attrition distribution in the country as most of the people on ART were linked to the ePMS (Ministry of Health and Child Care and National AIDS Council, 2017).

6.2.2 Study Site

This study was done in Zimbabwe. The country is made up of eight provinces (Matabeleland North, Matabeleland South, Masvingo, Midlands, Mashonaland East, Mashonaland Central, Mashonaland West and Manicaland) and two metropolitan cities (Harare and Bulawayo). The HIV prevalence varies by province due to significant heterogeneity in social, cultural and population dynamics that are mainly influenced by the geographical correlation of the epidemic. From the Zimbabwe Population-based HIV impact assessment (ZIMPHIA) survey in 2015/16, Matabeleland South and Matabeleland North provinces had a high HIV prevalence of 22.3% and 20.1%, respectively (Zimbabwe Ministry of Health and Child Care (MOHCC), 2017). The provinces are further divided into 60 districts that are the spatial unit of analysis for this study (Fig. 6.1); however, these districts are further partitioned into 1980 administrative wards.

Fig. 6.1 The map of Zimbabwe showing district names and codes.

6.2.3 Data Source

The data for this study were extracted from the Zimbabwe national ePMS database that compiles HIV monitoring information among ART patients described elsewhere (Mutasa-Apollo et al., 2014). Only patients aged 15 years and above who initiated ART between 2004 and 2017 were considered in this study. The ART services in Zimbabwe have been decentralised to approximately 1566 health facilities across the country in 2017 (Ministry of Health and Child Care and National AIDS Council, 2017). The distribution of the 538 health facilities considered in this study, whose coordinates are defined by the red dots, is shown in Fig. 6.2. The decentralisation of these health facilities resulted in increased access to ART for all those in need and improved ART uptake in the country.

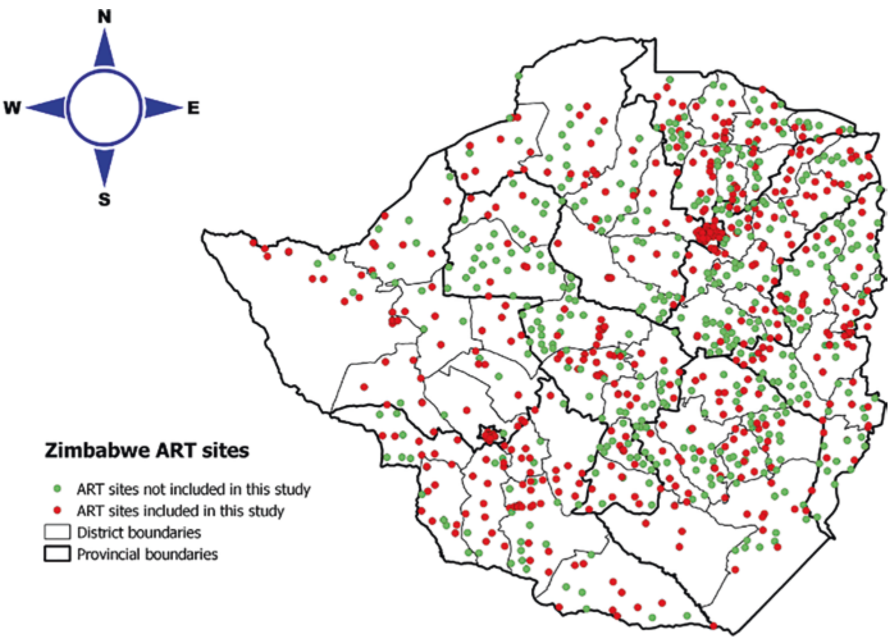

Fig. 6.2 The map of Zimbabwe with provinces and district demarcations showing the geographical points of the ART health facilities used in this study (red dots)

6.2.4 Study Variables

Outcome Variable and Censoring
ART attrition was defined based on several ART outcomes, which are death, withdrawal/opt-out, drop-out and LTFU. LTFU was defined as a failure of a patient to report for drug replenishment within 90 days from the last appointment date or if the patient missed the next scheduled visit date and never showed up again. Patients, who returned after having been LTFU, were classified as engaged/retained in care. The time variable was defined from ART initiation to the time when ART attrition occurred. Those who remained in care were right-censored till the end of 31 December 2017. Those who transferred (changed service provider) were censored on their last observed visit.

Independent variables
The database captures individual-level monitoring information; and the variables included in this study were health facility levels (quaternary, tertiary, secondary and primary levels of care), sex (male and female), tuberculosis status (positive and negative), marital status (single, married, widowed and divorced), body functional status (working, bedridden and ambulatory), age at ART initiation, WHO clinical stage (I/II and III/IV), year initiated on ART (2004–2007, 2008–2012 and 2013–2017).

6.2.5 Statistical Analysis

The survival model

The geo-additive model is described elsewhere (Adebayo & Fahrmeir, 2005; Hennerfeind et al., 2006). Let T denotes the survival time where $t \in \{1, 2, \ldots, q + 1\}$ defines the time in years after ART initiation. Let $z_t^* = \left(z_1, \ldots, z_t\right)$ denotes the history of a covariate at year t. The conditional probability of ART attrition at year t is then defined by

$$\lambda\left(t, z_t^*\right) = P\left(T = t | , T \geq t | , z_t^*\right), t = 1, 2, \ldots, q \tag{6.1}$$

The survival information is recorded by (t_i, δ_i), $i \in \{1, \ldots, N\}$ where $t_i \in \{1, \ldots, 14\}$ denotes the individuals' survival time in years, and δ_i is the censoring indicator with values 1 if attrition (mortality, LTFU, withdrawal and drop-outs) occurs or 0 otherwise. In other words, t_i represents either the years since the ART initiation of an individual at the time of attrition ($\delta_i = 1$) or the years since ART initiation at the last observed study time ($\delta_i = 0$). Non-informative censoring was assumed in this study as described elsewhere (Lagakos, 1979). The risk set R_t includes all individuals who are censored in the interval ending in t.

The binary event indicator for attrition $y_{it}\{i \in R_t, t = 1, \ldots, t_i\}$ was defined as follows:

$$y_{it} = \begin{cases} 1 \text{ if } t = t_i \text{ and } \delta_i = 1 \\ 0 \text{ otherwise} \end{cases} \tag{6.2}$$

The attrition process of an individual i was considered as a sequence of a binary event, that is, leaving the ART programme at a time $t(y_{it} = 1)$ or staying in the ART programme beyond time $t(y_{it} = 0)$.

Model covariates

Parallel to the sequence of the binary event, explanatory variables were considered. The binary indicator (y_{it}) was linked with the fixed covariates $\left(z_{it}^{*}\right)$ by a logit link function and a linear predictor ($\eta_{it}(z_{it})$). The conventional model is written as follows

$$P\left(y_{it} = 1 | \eta_{it}\right) = \frac{\exp\left(\eta_{it}\right)}{1 - \exp\left(\eta_{it}\right)} \tag{6.3}$$

While the linear predictor was defined as follows:

$$\eta_{it} = f_0\left(t\right) + z_{it}^{*}\beta \tag{6.4}$$

where $f_0(t)$, $t = 1, 2, \ldots$ is an unknown baseline effect, which is usually a non-linear smooth effect of t that is to be estimated from the data and β is the vector of fixed covariates effects such as marital status, gender, tuberculosis status, year of ART initiation and body functional status.

To account for the non-linear effects of metrical covariates as smoothing functions and spatial random effects, a flexible semiparametric predictor is utilised instead of the strict linear predictor (Eq. 6.3). Therefore, the flexible semiparametric predictor is defined as follows:

$$\eta_{it} = f_0\left(t\right) + f_1\left(X\right) + f_{\text{spat}}\left(s_i\right) + z_{it}^{*}\beta \tag{6.5}$$

where $f_0(t)$ is the baseline function of time and f_1 is a non-linear smooth effects of a continuous variable X which defines the age at ART initiation. The parameter $f_{\text{spat}}(s_i)$ is the non-linear spatial components of the district $s(s = 1, 2, \ldots, 60)$ where the individual was registered for ART. The spatial effect was split into spatially correlated (structures) ($f_{\text{str}}(s_i)$) and uncorrelated (unstructured) ($f_{\text{unstr}}(s_i)$) effects.

$$f_{\text{spat}}\left(s_i\right) = f_{\text{str}}\left(s_i\right) + f_{\text{unstr}}\left(s_i\right) \tag{6.6}$$

Splitting the spatial effects helps to detect unobserved heterogeneity in the outcome, which may be explained by strong spatial structures or may be present locally.

Through estimating the structured and unstructured effects, the aim is to separate the two kinds of factors. The spatial dependency in the data is easily observed and the spatial effect that contributes the most is detected and this is common in spatial epidemiology studies (Besag et al., 1991).

Three models were fitted in this study which are:

Model 1:

$$\eta_{it} = f_0(t) + f_1(\text{age at ART initiation}) + z_{it}^{*}\beta \tag{6.7}$$

Model 2:

$$\eta_{it} = f_0(t) + f_1(\text{age at ART initiation}) + f_{\text{unstr}}(\text{district}) + z_{it}^{*}\beta \tag{6.8}$$

Model 3:

$$\eta_{it} = f_0(t) + f_1(\text{age at ART initiation}) + f_{\text{unstr}}(\text{district}) + f_{\text{str}}(\text{district}) + z_{it}^{*}\beta \tag{6.9}$$

Model estimation-Bayesian priors for all unknown parameters

Since we implemented a fully Bayesian approach, all unknown parameters were assumed to be random; hence, prior information was assigned to these parameters. Non-informative or independent diffuse priors $P(\beta) \propto$ const were assigned to the fixed-effects parameters. Alternatively, highly dispersed Gaussian priors could be used.

The nonlinear functions can be modelled through knot selection or smoothness prior. In this study, the later was considered. The baseline effects ($f_0(t)$) were assumed Bayesian P-spline priors (Brezger & Lang, 2006), which assume that the unknown smooth function f of a particular covariates x can be approximated by a spline of degree l defined on a set of equally spaced knots $x(\max) = \varsigma_0 < \varsigma_1 < \varsigma_2 < \ldots < \varsigma_{s-1} < \varsigma_s = x(\max)$ within the main domain of x. The spline can be written in terms of the linear combination of $m = s + l$ B-spline basis function B_t, that is,

$$f(x) = \sum_{t=1}^{m} \beta_t B_t(x) \tag{6.10}$$

The functions B_t are defined locally in the sense that they are nonzero only on a domain spanned by $2 + l$ knots. The vector $\boldsymbol{\beta} = (\beta_1, \ldots, \beta_m)$ corresponds to the vector of unknown regression coefficients. Regression splines depend on the choice of the number of knots and their positions. With too few knots, the resulting spline may not be flexible enough to capture the variability of the data while too many knots may tend to overfit the data and result in too rough functions. An optimum number of knots (between 20 and 40) are normally used to ensure flexibility and define the roughness penalty based on the differences of adjacent regression coefficients to guarantee sufficient smoothness of the fitted curves. In this study, 40 knots were considered for the baseline effects.

The differences penalties were replaced with the second-order random walk priors for the non-linear f_1 functions regression coefficients. Let $f_1 = \{f(1), \ldots, f(m), m \leq n\}$ be a vector of corresponding function evaluation at the observed values of x. The generic format of the prior for f_1 is

$$f_1 \mid \tau_f^2 \propto \exp\left(-\frac{1}{2\tau_f^2} f_1' K f_1\right) \tag{6.11}$$

where K is the penalty matrix that penalises too abrupt jumps between neighbouring parameters. The amount of smoothness is controlled by the variance parameter τ_f^2 that controls the trade-off between flexibility and smoothness. The larger the variance, the rougher the estimated functions, while the smaller the variance, the smoother the estimates. Normally, a highly dispersed but proper hyper-prior is assigned to τ_f^2 estimate the smoothness parameter simultaneously with f_1. Then a first- and second-order random walk prior for f_1 are defined by

$$\begin{aligned} &f_1(t) = f_1(t-1) + u(t) \text{and} \\ &f_1(t) = 2f_1(t-1) - f_1(t-2) + u(t) \end{aligned} \tag{6.12}$$

respectively, with Gaussian errors $u(t) \sim N(0, \tau^{u}{}_2)$ and diffuse priors for the initial values. The first-order random walk penalised abrupt jumps $f_1(t-1) + u(t)$ between successive states and the second-order random walk penalised deviation from linear trend $2f_1(t-1) - f_1(t-2)$. The random walk may be equivalently defined by specifying the conditional distribution of parameters $f_1(t)$ given its side neighbours. The random walk can be interpreted in terms of the locally polynomial, that is, the first-order random walk corresponds to the locally linear and a second-order random walk to a locally quadratic fit to the neighbours.

The spatial effects were modelled separately to distinguish between the different effects on the outcome, that is,

$$f_{\text{spat}}(s_i) = f_{\text{str}}(s_i) + f_{\text{unstr}}(s_i). \tag{6.13}$$

For the spatial correlated (structured) effects, ($f_{\text{str}}(s)$), we assumed a Gaussian Markov Random Field (GMRF) prior common in spatial statistics was used (Besag et al., 1991). The GMRF priors reflect spatial neighbourhood relationships, that is, areas neighbours if they share a common boundary and assume that the effect of an area $s \in \{1, 2, 3, \ldots, S\}$ is conditional, spatially autoregressive with a Gaussian distribution. The spatial smoothness prior for the spatial function evaluation $f_{\text{str}}(s_i)$ was given by:

$$f_{\text{str}}(s) \mid f_{\text{str}}(r) r \neq s, \sigma^2 \sim N\left(\sum_{r \in \partial_s} f_{\text{str}}(r) / N_s, \tau_{\text{str}}^2 / N_s\right) \tag{6.14}$$

where N_s is the number of adjacent districts and $r \in \partial_s$ denotes the district r is not a neighbour of district s. Thus, the conditional mean of $f_{\mathrm{str}}(s)$ is an unweighted average of function evaluations of neighbouring districts. The variance parameter τ^2_{str} controls for smoothness. The unstructured (uncorrelated) spatial effects $f_{\mathrm{unstr}}(s)$ were assumed to be i.i.d Gaussian priors, $f_{\mathrm{unstr}}(s) \mid \tau^2_{\mathrm{unstr}} \sim N(0, \tau^2_{\mathrm{unstr}})$. In real situations, usually, it is not known how much spatial variation is explained by both the structured and the unstructured effects; therefore, the interpretation of the spatial effects is based on the sum of the two effects.

The variance parameter vector $\tau_j^2 = (\tau_f^2, \tau^2_{\mathrm{str}}, \tau_u^2, \tau^2_{\mathrm{unstr}})$ of the structured spatial effects, unstructured spatial effects and the error terms are estimated simultaneously with the unknown non-linear functions f_j. Therefore, these hyperpriors were assigned Inverse Gamma distribution with hyper-parameters a and b, $(\tau_j^2 \sim \mathrm{IG}(a_j, b_j))$.

$$P(\tau_j^2) \propto \frac{1}{(\tau_j^2)^{a_j+1}} \exp\left(\frac{b_j}{\tau_j^2}\right), \text{for } \mathrm{a}_j, \mathrm{b}_j > 0 \tag{6.15}$$

The choice of the hyper-parameters values was $a_j = 1$ and $b_j = 0.005$.

Markov Chain Monte Carlo Inference for the posterior distribution

Fully Bayesian inference is based on the posterior distribution of the model parameters, whose form is unknown. Let α denotes the vector of all unknown parameters in the model. Under the conditional independence assumptions, the posterior distribution is given by

$$\begin{aligned} P(\alpha \mid \mathrm{y}_{it}) \propto \prod_{i=1}^{n} L_i(y_{it}, \eta_{it}) \times \prod_{j=1}^{P} \left\{ p(\beta_j \mid \tau_j^2)\, p(\tau_j^2) \right\} \\ \times p(f_{\mathrm{str}} \mid \tau^2_{\mathrm{str}}) \times p(f_{\mathrm{unstr}} \mid \tau^2_{\mathrm{unstr}}) \end{aligned} \tag{6.16}$$

The posterior model was estimated using the MCMC sampling technique from full conditionals for non-linear effects, spatial effects, fixed effects and smoothing parameters implemented in BayesX. For nonlinear and spatial effects, the iteratively weighted least squares (IWLS) sampling scheme was used.

Model selection

Three models were fitted in this study to compare the impact of covariates and compare the geo-additive models with simpler models. The model comparison intends to select the model that has all relevant covariates while remaining parsimonious. The Deviance Information Criterion (DIC) was used, which is defined as

$$\mathrm{DIC}(M) = \overline{D(M)} + pD \tag{6.17}$$

where $\overline{D(M)}$ is the posterior mean of deviance, which is a measure of the goodness of fit model, M, and is penalised by an effective number of model parameters pD measuring the complexity of the model. The smaller the DIC value the better the model.

Model diagnostics and sensitivity analysis
The convergence of the Markov chains to their stationary distributions was assessed by inspecting the sampling paths and autocorrelation functions of the sampled parameters. Trace plots and visual autocorrelation plots were used to evaluate the performance of the model. In running the MCMC algorithm, 10,000 iterations were made with a burn-in of 2000 and a thinning parameter of 10. We also performed a sensitivity analysis to ensure that the choice of the priors did not influence the obtained results. In the initial run, default Gamma priors with hyper-parameters ($\alpha = \beta = 0.001$)) were used then two more trials using values of $\alpha = \beta = 0.0001$ and $\alpha = 1$ with $\beta = 0.001$. The results reported are those of the model with default prior values.

6.3 Ethics

The permission to use the routinely collected HIV data among ART patients was sort and granted by the Zimbabwe Ministry of Health and Child Care through the AIDS/TB Unit, which oversees the data collection and storage. Ethical approval was granted by the University of Witwatersrand's Human Research Ethics Committee (Medical) (Clearance Certificate No. M170673). Since this was a secondary data analysis, consent to participate from the participants was not applicable.

6.4 Results

6.4.1 Descriptive Statistics

A study sample of 372,125 was considered for analysis. All individuals had initiated ART for at least one year and the maximum follow-up time was 14 years. The descriptive characteristics of the individuals are summarised in Table 6.1.

The mean age was 37.4 ± 11.4 years, 4.9% of the study participants initiated ART between 2004 and 2007, 39.5% initiated ART between 2008 and 2013 and 55.6% initiated ART between 2013 and 2017. At ART initiation, most of the patients were female (65.7%), married (59.5%) and 50.3% were enrolled in district/mission hospitals. Most patients were classified in WHO clinical stage III/IV (55.1%), 34.18% were in the 35–44 years age group, a few had confirmed HIV-tuberculosis coinfection (1.1%), and only 6.44% of patients had either an ambulatory (6.1%) or a bed-ridden (0.2%) body functional status.

Table 6.1 The descriptive characteristics of the adult ART patients in the HIV programme cohort in Zimbabwe

Characteristics	Categories	Period of ART initiation n(%) 2004–2007 18.449(4.9%)	2008–2012 146,808(39.5%)	2013–2017 206,808(55.6%)	Total $N = 372,125$
Patient Demographics					
Age (years) at ART initiation	mean ± SD	39.1 ± 10.5	38.4 ± 11.4	36.5 ± 11.4	37.4 ± 11.4
Sex	Females	12,219(66.2%)	95,619(65.1%)	136,613(66.0%)	244,451(65.7%)
	Male	6230(33.8%)	51,189(34.9%)	70,255(34.0%)	127,674(34.3%)
Marital status at ART initiation	Single	2009(10.9%)	17,437(11.9%)	29,791(14.5%)	49,237(13.2%)
	Married	9202(49.9%)	83,071(56.6%)	129,153(62.4%)	221,426(59.5%)
	Widowed	5269(28.6%)	29,054(19.8%)	24,174(11.7%)	58,497(15.7%)
	Divorced	1295(7.0%)	11,195(7.63%)	15,591(7.5%)	28,081(7.6%)
	Missing	674(3.7%)	6051(4.12%)	8159(3.9%)	14,884(4,0%)
Health facility	Primary care	6603(35.8%)	53,257(36.3%)	103,083(49,8%)	162,942(43.8%)
	District/Mission	8895(48.2%)	82,918(56.5%)	95,466(46.2%)	187,279(50.3%)
	Provincial/Referral	2951(16.0%)	10,633(7.2%)	8320(4,0%)	21,094(5.9%)
Clinical factors					
WHO staging at ART initiation	I/II	3427(18.6%)	44,818(30.5%)	100,807(48.7%)	149,052(40,1%)
	III/IV	13,221(71.7%)	96,028(65.4%)	95,724(46.3%)	204,973(55.1%)
	Missing	1801(9.8%)	5962(4.1%)	10,337(5.0%)	18,100(4.95)
Tuberculosis status at ART initiation	Negative	16,375(8.8%)	129,351(88.1%)	184,752(89.35)	330,478(88.85)
	Positive	128(0.7%)	1093(0.7%)	2863(1.4%)	4084(1.1%)
	Not assessed	1596(8.7%)	14,022(9.6%)	16,796(8.1%)	32,414(8.7%)
	Missing	350(1.9%)	2342(1.6%)	2457(1.25)	5149(1.45)
Body functional status at ART initiation	Working	17,258(93.5%)	135,845(92.5%	193,190(93.4%)	346,293(93.1%)
	Ambulatory	889(4.85)	9664(6.7%)	12,221(5.9%)	22,774(6.1%)
	Bed-ridden	48(0.3%)	230(0.2%)	369(0.2%)	6,47(0.2%)
	Missing	254(1.4%)	1069(0.7%)	1088(0.5%)	2411(0.75)

Missing means the information was not captured in the dataset for those individuals

6.4.2 Choropleth Map–Observed Attrition Rates at the District Level

The percentage of ART attrition in this cohort was 30.6% (n = 114,022) with a 95% confidence interval (CI) of 30.5–30.8%. The ART attrition rate was 74 (95%CI: 73.6–74.5) per 1000 person-years. The observed geographical distribution of attrition is shown in Fig. 6.3.

The ART attrition ranged from 17.3% to 56.6% across districts. The districts with the highest attrition within the range of 42.3–56.6% were Bulawayo (1), Harare (2) and Chegutu (26). There were 12 districts with ART attrition in the range of 33.8–42.3% of which four of these districts (Beitbridge (46), Matobo (51), Hwange (41) and Nyanga (9)) border Botswana, South Africa and Mozambique.

6.4.3 Model Selection and Fixed Effect Estimates

Three models were fitted which are the no spatial random effects model (model 1), the unstructured spatial effects model (model 2) and the convolutional model (model 3). The DIC, pD and deviance estimates were used to determine the best model for the analysis. The convolutional model was the best in this study as it had the lowest DIC value of 85.

Based on the convolutional model, and as shown in Table 6.2, Cox regression showed that the factors predicting attrition were being enrolled at a provincial/

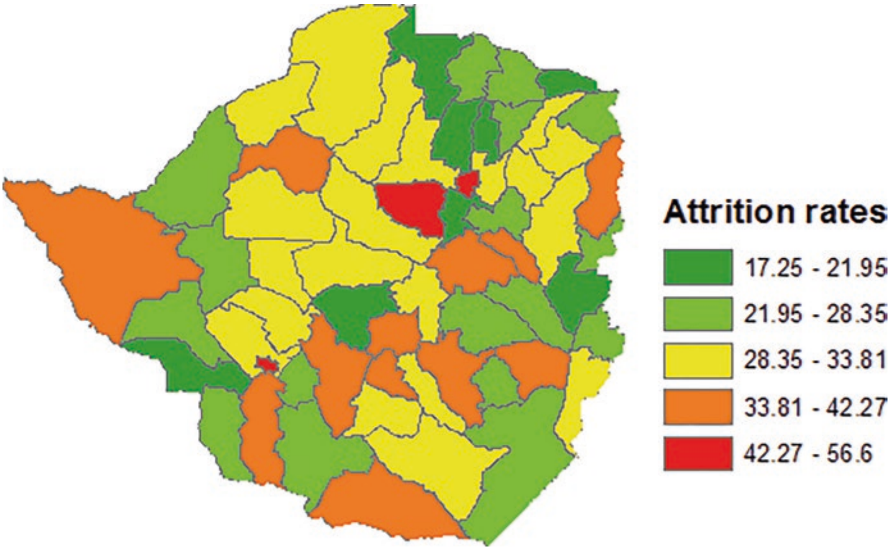

Fig. 6.3 The choropleth map for attrition rates at the district level

Table 6.2 Bayesian estimates of posterior means of the fixed-effect parameters

Variables		Geo-additive model building				
	Without spatial random effects		Unstructured spatial random effects		Convolutional model	
	Coefficient (95%CrI)	Risk ratio (95%CrI)	Coefficient (95%CrI)	Risk ratio (95%CrI)	Coefficient (95%CrI)	Risk ratio (95%CrI)
Health facility level						
Primary	Reference	Reference	Reference	Reference	Reference	Reference
Secondary	0.161(0.147 to 0.175)	1.175(1.158 to 1.191)	0.255(0.241 to 0.269)	1.291(1.272 to 1309)	0.815(0.793 to 0.833)	**2.259(2.211 to 2.301)**
Tertiary	0.238(0.216 to 0.264)	1.269(1.241 to 1.302)	0.253(0.219 to 0.282)	1.287(1.245 to 1.326)	0.926(0.873 to 0.967)	**2.524(2.394 to 2.63)**
Sex						
Female	Reference	Reference	Reference	Reference	Reference	Reference
Male	0.078(0.079 to 0.088)	1.081(1.082 to 1.092)	0.074(0.062 to 0.086)	1.077(1.064 to 1.089)	−0.891(−1.054 to −0.773)	**0.41(0.348 to 0.462)**
WHO clinical stage						
I/II	Reference	Reference	Reference	Reference	Reference	Reference
III/IV	−0.283(−0.295 to −0.272)	0.754(0.745 to 0.762)	−0.289(−0.299 to −0.275)	0.749(0.742 to 0.759)	−0.056(−0.071 to −0.041)	**0.946(0.931 to 0.959)**
Tuberculosis co-infection						
No	Reference	Reference	Reference	Reference	Reference	Reference
Yes	0.881(0.834 to 0.769)	2.413(2.303 to 2.158)	0.764(0.722 to 0.808)	0.466(0.486 to 0.446)	1.278(1.191 to 1.361)	**3.589(3.291 to 3.911)**

(continued)

Table 6.2 (continued)

Variables	Geo-additive model building					
	Without spatial random effects		Unstructured spatial random effects		Convolutional model	
	Coefficient (95%CrI)	Risk ratio (95%CrI)	Coefficient (95%CrI)	Risk ratio (95%CrI)	Coefficient (95%CrI)	Risk ratio (95%CrI)
Marital status						
Single	Reference	Reference	Reference	Reference	Reference	Reference
Divorced	0.042(0.019 to 0.063)	1.043(1.019 to 1.065)	0.005(−0.021 to 0.029)	1.005(0.979 to 1.029)	0.199(0.159 to 0.238)	**1.22(1.172 to 1.269)**
Widowed	−0.189(−0.219 to −0.169)	0. 827(0.803 to 0.844)	−0.206(−0.021 to −0.181)	0.814(0.979 to 0.834)	0.107(0.073 to 0.139)	**1.112(1.076 to 1.149)**
Married	−0.104(−0.103 to −0.089)	0.901(0.902 to 0.914)	−0.116(−0.228 to −0.181)	0.891(0.769 to 0.834)	0.095(0.073 to 0.113)	**1.099(1.078 to 1.119)**
Functional status						
Working	Reference	Reference	Reference	Reference	Reference	Reference
Ambulatory	0.248(0.221 to 0.269)	1.281(1.247 to 1.309)	0.357(0.332 to 0.381)	1.429(1.394 to 1.464)	0.729(0.728 to 0.765)	**2.073(2.071 to 2.149)**
Bedridden	0.683(0.588 to 0.769)	1.979(1.801 to 2.158)	0.677(0.594 to 0.772)	1.968(1.811 to 2.164)	1.413(1.223 to 1.617)	**4.108(3.397 to 5.038)**
Period of ART initiation						
2004–2007	Reference	Reference	Reference	Reference	Reference	Reference
2008–2012	1.023(0.949 to 1.072)	2.782(2.583 to 2.921)	1.084(1.035 to 1.182)	2.956(2.815 to 3.261)	−2.459(−2.546 to −2.378)	**0.086(0.078 to 0.107)**
2013–2017	3.423(3.312 to 3.495)	30.66(27.43 to 32.95)	3.508(3.461 to 3.599)	33.39(31.849 to 36.56)	−2.969(−2.968 to −2.877)	**0.051(0.051 to 0.056)**
Model diagnostics						
Deviance	655632.47		640713.23		336562.14	
pD\	434.51		363.10		85.17	
DIC	656501.48		641439.42		336732.47	

referral (hazard ratio (HR) = 2.25; 95% credible interval (CrI): 2.211 to 2.301) or district/mission (HR = 2.5; 95%CrI: 2.394 to 2.63) hospitals compared to being enrolled at a PHC. Male patients (HR = 0.41; 95%CrI: 0.348 to 0.462) and those in WHO clinical stage III/IV (HR = 0.946; 95%CrI: 0.931 to 0.959 were less likely of ART attrition. Tuberculosis-infected patients (HR = 3.589; 95%CrI: 3.291 to 3.911), those who had an ambulatory body (HR = 2.07, 95%CrI: 2.071 to 2.149) or bedridden body (HR = 4.1, 95%CrI: (3.397 to 5.038) had an increased risk of ART attrition. Those who initiated ART between 2008 and 2012 (HR = 0.086, 95%CrI: 0.078 to 0.107) and 2013 to 2017 (HR = 0.051; 95%CrI: 0.051 to 0.056) were less likely of ART attrition.

6.4.4 Non-linear Effects Plots Based on the Convolutional Model

Figure 6.4 shows the non-linear effects of age at ART initiation and baseline effect. The risk of ART attrition increased with an increase in the number of years on ART in this study. The longer an individual stays in the ART programme the more the risk of ART attrition after 8 years. In the first 8 years of ART initiation, the results show a protective effect of ART attrition. The 20-year-olds had the highest risk of ART attrition compared to the other age groups. Those aged 15–20 years and 70–75 years had an increased risk of ART attrition. Though the risk of ART attrition slightly decreased for those aged 20–60 years, a sharp decrease was observed for those aged 60–70 years.

6.4.5 Spatial Effects Based on the Convolutional Model

The spatial random effects were split into structured (correlated) effects and unstructured (uncorrelated) effects. The spatial dependency was more expressed in the unstructured spatial effects with RR ranging from 0.433 to 2.75, while the structured spatial effects had lower RR which ranged from 0.97 to 1.03. Since the unstructured spatial effects exceeded the structured spatial effects, the spatial dependency of ART attrition in this study was smaller. The ART attrition spatial variations from the geo-additive survival model are displayed in Fig. 6.5.

A district-specific geographical variation in ART attrition across the country was very distinct. Unstructured spatial effects showed ART attrition hot spots that were detected in Harare (2) and Bulawayo (1) metropolitan cities with an estimated ART attrition risk ratio of 2.75. However, there was a significant increase in ART attrition risk among those in Hwange (41), Chegutu (26), Chipinge (5), Bikita (32), Kwekwe (57), Chikomba (17), Wedza (25) and Nyanga(9). The structured spatial effects

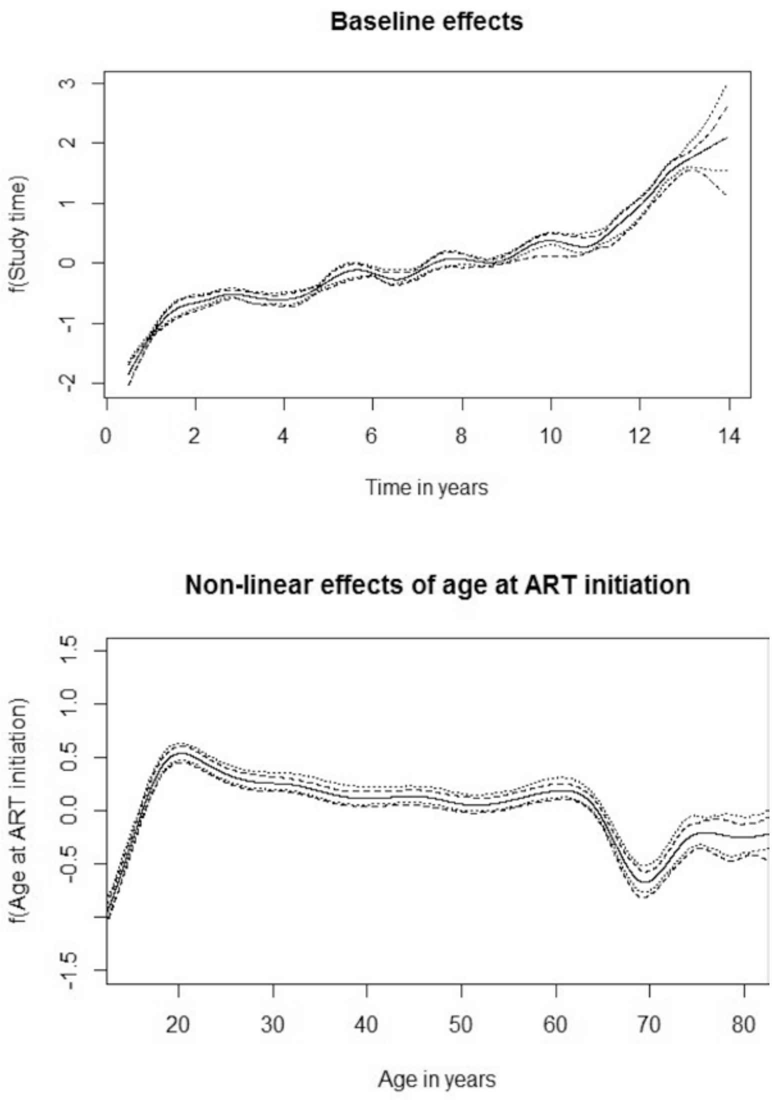

Fig. 6.4 The non-linear effects of baseline effects (top) and age at ART initiation (bottom)

reflect a clear spatial heterogeneity across the country and relative spatial homogeneity among neighbouring districts.

There was a clear spatial correlation with neighbouring effects in the following districts: Beitbridge district (46), Mwenezi (37), Chiredzi (33), Chivi (34), Masvingo (36), Bikita (32) up to Wedza (25), Harare (2), Goromonzi (18) and Mt Darwin (14), which indicates higher ART attrition rates in these districts and these also constituted the observed hot spots for ART attrition.

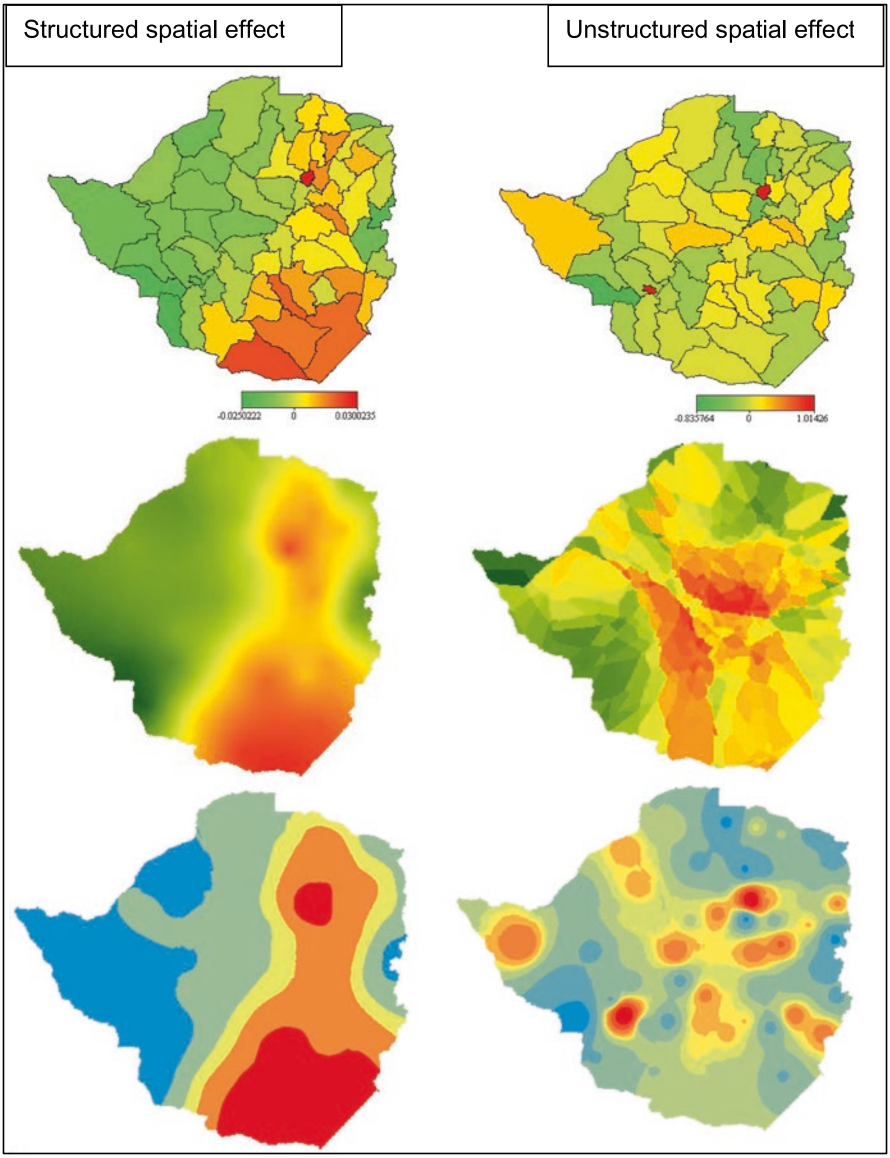

Fig. 6.5 The posterior mean of structured (left) and unstructured (right) spatial effects based on the convolutional model

6.5 Discussion

The main objective of this study was to describe the spatial heterogeneity of ART attrition rates in Zimbabwe before the implementation of the HIV "treat all" strategy and identify the hot spots for ART attrition using routinely collected patient-level data. This study is the first to utilise the geo-additive survival model to predict ART attrition and identify associated hot spots. The identification of ART attrition hot spots is more appealing during this period of the HIV "treat all" strategy.

ART attrition was estimated at 30.6% in this study, which is relatively high. This ART attrition rate estimate is comparable to a recent study conducted in Zimbabwe using a similar cohort that reported an ART attrition rate of 25.6% after a 3-year follow-up period before the HIV "treat all" strategy implementation. In Nigeria, an ART attrition rate of 34% was reported among those who were under the HIV "treat all" arm (Stafford et al., 2019), while another study in Zimbabwe that looked at ART attrition in Manicaland province reported an ART attrition rate of 50% during the "treat all" strategy (Tlhajoane et al., 2021). These results put forward the need for alertness that is required in HIV programmes so that the optimum benefits of the HIV "treat all" strategy can be attained.

The fixed effects covariates that were significant correlates of ART attrition included health facility level, body functional status and tuberculosis coinfection. These covariates are similar to what has been reported in other studies (Makurumidze et al., 2020b; Zingoni et al., 2020). The high risk of ART attrition among those enrolled in higher levels of care can be attributable to the introduction of decentralisation of the health services to primary health care (Ferrand et al., 2017; Mutasa-Apollo et al., 2014). Presumably, travel distance plays a significant role in explaining these findings as patients prefer to enrol in nearer health sites, especially those in rural areas with transport challenges. Contrary, most ill patients are referred to higher levels of care for advanced care and ultimately demise due to their severe illnesses; hence, these health facilities will report many ART attrition outcomes (Fatti et al., 2010). Those patients with ambulatory and bedridden were more likely to experience ART attrition in this study, and this can be explained by the fact that these patients are normally critically ill so most of them eventually become LTFU or die due to their critical condition (Gezie, 2016). HIV-tuberculosis co-infections cannot be over-emphasised. The risk of ART attrition in the HIV-tuberculosis group can be explained by the difficulty in patient-care management faced in this group and the limited integrative options for the treatment of both infections (Takarinda et al., 2017).

The non-linear baseline effects showed that the longer an individual stays in the ART programme, the more the risk of ART attrition, and this supports the main goal of potent and effective ART treatment of prolonging survival (Rachlis et al., 2017). The risk of ART attrition starts to be evident after the first 8 years of ART, which shows how effective the monitoring system is and how engaging the patients are during the early years of ART. This finding supports other studies which observed low ART attrition (LTFU) rates among patients after 5 years of being on ART (Jiamsakul et al., 2019). Interestingly, this study observed that those aged 20 years had the highest risk of ART attrition. This finding supports previous studies that have shown that adolescence and young adults have poor HIV outcomes and are less likely to achieve and sustain viral suppression due to the lack of psychosocial support (Mark et al., 2020).

The smooth structured spatial effects show that patients from the regions that border South Africa, that is, the Beitbridge to Harare band, were at risk of ART attrition. This finding could be supported by the fact that this region has a lot of migration of Zimbabweans visiting neighbouring countries for job seeking. As a result, most HIV patients, especially those who reside along the Beitbridge border, tend to cross to South Africa for health care and employment and are then classified as LTFU. Therefore, patient tracing should be strengthened in these settings to minimise the misclassification of ART outcomes (Geng et al., 2016). The results also show clear hot spots for ART attrition from the unstructured spatial effects that include the Hwange district with borders Zambia and Nyanga/Chipinge districts that border Mozambique and inland hot spots. In these spots, targeted interventions that minimise excessive utilisation of resources can be implemented to minimise ART attrition including community engagements, male involvement and educational promotion on the benefits of ART (Price et al., 2017).

6.6 Research Implication

The HIV "treat all" approach is a novel intervention in the fight against HIV that comes with challenges to the healthcare system, especially, in settings where the healthcare system is strained. The HIV "treat all" means a swift influx of asymptomatic PLWHIV in the ART cohort, which may lead to high rates of ART attrition. This study's findings imply that there is a need to expand the decentralisation of ART services in communities to increase ART access as the number of people on ART increases due to the "treat all" strategy (Takarinda & Mutasa-Apollo, 2016). Because of the high influx of PLWHIV at health facilities, there is a need to decongest the facilities and have less frequency to clinic attendances and medication pick up to motivate ART patients to always return for their scheduled appointments and drug refills (Takarinda & Mutasa-Apollo, 2016). Operational research should be strengthened to help systematically identify patients' healthcare access barriers. With the high rates of ART attrition observed in this study, there is a need to strengthen continuous counselling sessions, especially for the asymptomatic PLWHIV, of the importance of ART adherence. The main focus should be on those patients who are late for ART refills or missed scheduled appointments as these subsequently experience ART attrition. Priority should be given to patients who access care from remote areas and implementing a retention support system by community health workers may be fruitful. The ePMS should have an efficient active patient-tracking component for all patients on ART that reduce ART attrition from care and minimise sub-optimal adherence (Harries et al., 2010). The ART programme should have an efficient follow-up mechanism that tracks everyone, especially, those in the hot-spots regions. There is also a need for differentiated care strategies for adolescents subpopulation to improve retention (Harries et al., 2010).

6.7 Study Limitations and Future Research

Our findings should be interpreted cautiously, and participants used in this study were conveniently sampled from the ePMS database and might not be a true representation of all ART patients in Zimbabwe; however, health sites with high volumes of patients were linked to the ePMS. Biased estimation of ART attrition rates could have occurred, due to differential misclassification of the ART attrition (LTFU). Some patients classified as LTFU may have been "silent transfers" who enrolled in a different health facility as a result of ART decentralisation or might have relocated across borders. With active patient tracing, these misclassifications could be minimised. Despite these limitations, important information regarding ART attrition and the associated spatial heterogeneity patterns was determined using the Bayesian geo-additive survival model. Moreover, spatial dependency in the data was easily observed and the spatial effect that contributes the most was detected to guide HIV programme planning. Moreover, the subpopulation groups of people with a high risk of ART attrition were identified.

The spatial unit of analysis was the district that is a relatively big administrative unit to implement interventions. The dataset used in this study did not support lower administrative units like wards; hence, future studies should consider utilising small area spatial analysis as these are much more informative and efficient for resource allocation and decision-making, especially in the hot spots' regions. Missing data was of concern, particularly to those variables that influence ART attrition like viral load and CD4 cell count in addition to non-communicable diseases and comorbidities. The presence of missing data could be explained by poor documentation of information (Molfino et al., 2014) or differential immunological monitoring implemented in Zimbabwe at the time (Mutasa-Apollo et al., 2014). Future studies should fact in such covariates in spatial models to get a precise estimate for ART attrition rates. ART drug resistance is another threat to the "treat all" that has not been substantially spatially analysed. Lastly, geo-referenced data is still scarce at low administrative units, and there is a need to utilise mobile phone technology to get coordinates while taking into account privacy (Harries et al., 2010). Data independent of national boundaries/national data collection practices should be encouraged to facilitate cross-country comparisons and multi-country analyses. This would be helpful for the future direction given the mobility of persons and the complexity of social networks.

6.8 Conclusion

As most countries have fully implemented the HIV "treat all" WHO guidelines, it is important to understand the spatial heterogeneity of ART attrition risk in Zimbabwe at the district level. Spatial analysis reveals patterns that support targeted interventions and resource allocation. However, currently, there is limited utilisation of spatial analysis to inform policy, guide planning and prioritise settings, particularly in resource-limited settings where poor ART outcomes are high. This study's findings show a clear spatial dependency of ART attrition in Zimbabwe. High-risk ART attrition regions have been identified and these should be prioritised to maximise retention in care in this era of the "treat all" strategy. This study recommends that the ePMS should be efficient in tracking patients, and continual counselling and educational support should be provided to all ART patients, particularly the asymptomatic group with emphasis on the benefits of ART and adherence. With all these efforts integrated intensively into the HIV programmes, the risk of ART attrition may become minimum and 95-95-95 UNAIDS targets can be archived while optimising the benefits of the HIV "treat all" strategy. Attaining this goal is a closer step toward attaining a minimum ART attrition rate in the HIV population. Once the reduction of ART attrition is achieved in Zimbabwe, this has a greater impact on the African continent. Resources that are channelled toward the HIV programme could be redirected to other neglected areas for further development of the country and the continent at large.

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Competing Interests None declared

Data Sharing Statement The data used for this study can be found from a third party through an application process to the Zimbabwe Ministry of Health and Child Care through the HIV/AIDS Unit which oversees the data collection and compilation process for the ART programme; therefore, the data is not publicly available.

Author's Contribution **ZMZ** and **EM** were responsible for the conceptualisation of this paper, and **ZMZ** performed all the data management, cleaning and analysis. **EM** oversaw the statistical analysis process. **ZMZ**, **EM**, **JT** and **TC** contributed to the analysis of the results. **ZMZ** drafted the manuscript/book chapter. **JT, TC and EM** reviewed the manuscript for intellectual content. All authors reviewed the final version for submission.

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Chapter 7
Mobility and Disease Diffusion in East Africa: The Case of HIV/AIDS, Ebola, and COVID-19

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7.1 Introduction

Diseases that plague human society have attracted attention from a wide range of disciplines including epidemiologists, population geographers, health geographers, and social scientists. Diseases occur globally but Africa has the largest infectious disease burden and the poorest health infrastructure in the world (WHO, 2014). Some of these diseases include measles, yellow fever, monkeypox, Ebola, rift valley fever, zika virus, and chikungunya virus, drawing attention on why some persist, or re-emerge, and what factors influence the spread of these diseases (Fenollar & Mediannikov, 2018). To monitor the spread of infectious diseases globally, the World Health Organization (WHO) uses data obtained from surveillance of the infectious diseases to help in monitoring and modeling future pandemics (WHO, 2000:110).

Two growing fields have dominated the study of disease, health geography, and the sister subdiscipline of medical geography. Health geography, also known as the geography of health, is concerned about the application of geographical information, perspectives, and methods, to study health, disease, and healthcare systems. Medical geography, focuses on understanding spatial patterns of health and disease as related to the natural and social environment and their expression in the health of people in places (Meade et al., 1998). Medical geography has two thematic interests, disease geography or geographical epidemiology, which is concerned with spatial patterns and processes of health and disease outcomes, and health systems planning for service provision (Earickson, 2009; Nepal, 2002; Mayer, 1982). Health and medical geography seek to "shift focus to disease ecology, disease mapping, and health

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service provision" (Brown et al., 2009), but the two subdisciplines of geography have different approaches to the study of disease. For example, in the study of HIV/AIDS in developed countries, the medical geography approach focused on mapping the distribution and diffusion of the virus, while health geographers interrogated the quality of life of persons living with HIV and the cultural and political issues affecting HIV/AIDS, such as the epidemiological surveillance systems and rights of persons living with HIV (Williams et al., 2009).

One of the landmark studies of medical geography is by John Snow, who studied the cause of cholera deaths in the UK and after mapping the cases of deaths discovered that they were all clustered around a specific water point in London. Using this knowledge, John Snow advised that the water point be closed, resulting in a reduction in the number of cholera-related deaths (Snow, 1855). By mapping cholera deaths and tracking them to the polluted water point, John Snow was able to deduct that cholera was a waterborne disease. The field of medical geography developed in the United States in the 1950s following observations by May (1950) of differences in health outcomes in Europe compared to South East Asia, in Thailand and Vietnam, where he had worked. This drew his interest in the connections between the environment and health outcomes, leading to the development of the medical geography subdiscipline that described the relationship between pathogen transmissions and geographical factors and how these influenced health outcomes (Meade & Emch, 2010; May, 1977).

Diseases vary spatially, with some occurring in specific locations, while not in others. The disease ecology model seeks to elaborate why diseases are spatially varied. Disease ecology framework argues that any disease may be attributable to three sets of factors – genetics, environment, and behavior. While genetics refers to biological attributes, the environment relates to the physical place where people live, while behavior refers to social and cultural choices, practices, and belief systems. At any given time, these three factors interplay to give rise to distinct disease ecologies or scenarios. Diseases are therefore environmental, influenced by the physical environments that create them, or infectious, caused by pathogens.

Disease occurrence can be perceived either as the location where they are found or as places where the necessary conditions for their occurrence are prevalent. In the case where diseases are based on their location, the main measure will be the number of individuals manifested the disease, or infected of it, as the case of cholera mapping by Snow (1855), that indicated that most individuals with the disease were living near a public pump, hence the hypothesis that cholera was spread by water. Rytkönen (2004) describes the benefits of disease mapping as this enables the description of the spatial variations in disease incidence, which can inform hypothetical considerations; for identifying locations with unusually high risk of diseases to allow for corrective action; and for a visual presentation of the disease risks in regions for policy action. In the alternative case, the focus of investigation is the cause of the prevalence of disease in a given area, identified as "risk areas" where individuals contract diseases owing to exposure to the risk factors associated with those given locations. Thus, disease diffusion can be understood as the "diffusion of cases" or the "diffusion of the causes and hazards" (Schærström, 2009).

Disease diffusion occurs when a disease is transmitted to a new location different from where it originated. Cromley (2003) describes five disease diffusion patterns: Expansion occurs when disease spreads from an epicenter, out to new areas. Relocation occurs when the disease spreads from an epicenter to other independent new locations. Contagious diffusion occurs when the disease spread through direct contact of individuals with those infected, while network diffusion occurs when the disease spread through transportation and social networks. Mixed diffusion occurs when there is a combination of contagious and hierarchal diffusion. The use of GIS techniques has been applied to improve understanding of diseases and their spatial distribution, including spatial analysis of diseases such as disease mapping and modeling, geographical epidemiology, and environmental epidemiology (Lyseen, et al., 2014; Cromley & McLafferty, 2011; Hornsby & Egenhofer, 2000).

7.1.1 The East African Community (EAC)

The EAC is a regional intergovernmental organization of currently seven (7) Partner States, comprising Burundi, Kenya, Rwanda, South Sudan, Tanzania and Uganda, and the new partner Democratic Republic of Congo. Established in 1967, the EAC initially comprised of Kenya, Tanzania, and Uganda. The regional bloc was dissolved after a fallout in 1977, but linkages were reestablished in 1993 when the Permanent Commission for East African Cooperation was established. The EAC was fully established in July 2000, when the Treaty for the Establishment of the East African Community entered into full force, with the objective of forming a regional political confederation. Rwanda and Burundi joined the EAC in 2007, while South Sudan joined in 2016. More recently, in April 2022, the Democratic Republic of Congo also joined the EAC following a formal signing of the Treaty of Ascension to the EAC.

For the purpose of this chapter, five of the EAC member states are covered, including Burundi, Kenya, Rwanda, Tanzania, and Uganda; see Fig. 7.1.

7.1.2 Mobility and Migration Patterns in EAC

Since pre-colonial periods, citizens of the East African Community region, especially Kenya, Tanzania, and Uganda, who formed the first Partner States of the EAC in 1967, freely moved and traded across their borders. The East Africa Regional Migration flows were influenced by colonial policies, resulting in the characteristic rural to urban migration flows within respective countries (Agwanda et al., 2022; Oucho, 1998, 2014; Ominde, 1965; Masser & Gould, 1975). The mobility patterns within respective East Africa are dominated by circulation, typified by seasonal movements between rural and urban areas, mostly in search of employment or through educational movements, as most institutions were located in urbanized

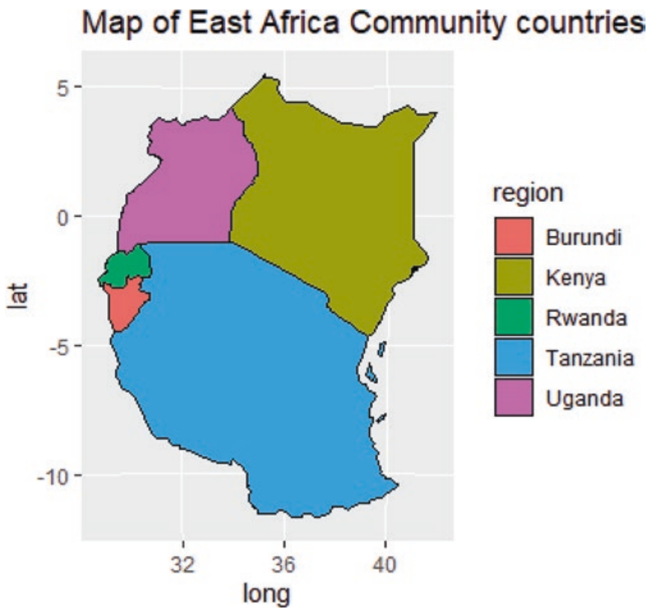

Fig. 7.1 Original partner states of the East African Community. (Source: Authors own generation using R program)

parts of the countries. Climate-induced agriculture is also prevalent owing to dependence on rain-fed agriculture (Agwanda et al., 2022; Oucho, 2009, 2014).

Forced migration has predominated the EAC region owing to civil wars resulting in refugees and asylum seekers crossing over the neighboring countries (Oucho, 2006). Prior to 2000, the Republic of Rwanda underwent the worst humanitarian crisis yet dubbed the "Rwandan Genocide" of 1994 following the civil war that saw Hutu militias killing members of the Tutsi community, resulting in a mass displacement of citizens to neighboring countries, especially Uganda and Zaire, present-day Democratic Republic of Congo.

Uganda hosts the largest number of refugees in the whole of Africa and the EAC region, majority of these from South Sudan and the Democratic Republic of Congo. According to the EAC Secretariat, the region has an estimated population of 195 million including nearly 5 million international migrants, over 2.8 million refugees and asylum seekers, and nearly 2.4 million internally displaced persons (IDPs) in the region, with all countries being nations of origin, destination and transit for migrants, and the displaced and other groups on the move (EAC Press Release, February, 2022).

As part of the aspirations of the EAC to form a common market and promote regional integration, the Free Movement of Persons Protocol was ratified in 2010, allowing citizens of the respective member states to move freely for trade and leisure between these countries. The Free Movement of Persons Protocol eased the movement of persons across the borders of EAC member states, by adaptation of an integrated border management system, removal of restrictions on movement of labor and services, and the right of establishment and residence. Despite the formalization of the One Stop Border (OSB) points to facilitate the screening of travelers, population mobility within the region continues through unregulated border points, creating a challenge in proper management and accounting of cross-border mobility in the region. Evidence from mobile data sources reveal that many citizens move within the porous borders of the EAC region (Pindolia et al., 2014). In the past, this has resulted in the spread of infectious diseases across the borders including cholera, dysentery, malaria, and hemorrhagic fevers like yellow fever, Ebola, and Rift Valley fever (Kebede et al., 2010), resulting in establishment of an EAC regional pandemic response mechanism within the EAC Disease Prevention and Control Unit. Two important projects within this unit include the establishment of the East African Public Health Laboratory Networking Project, which will ensure faster surveillance of TB and other communicable diseases, and the East African Integrated Disease Surveillance Network, to strengthen cross country collaborations to prevent and control diseases in the region.

7.2 Migration and Disease Diffusion

Human mobility and migration lead to faster contact between persons, resulting in the exposure of noninfected persons to disease pathogens. Globalization and rapid urbanization have made the world interconnected leading to easier opportunities for travel through air or land and greater connectivity between geographical regions. As a result, spread of infectious diseases is much faster, leading to outbreaks of pandemics. Even when movement is non-voluntary, people who move may transmit diseases from the new areas of settlement or get sick from existing diseases in the locations they move to. Several studies have focused on the nexus between migration and population mobility and disease diffusion globally (Li et al., 2021; Khatua et al., 2020; Findlater & Bogoch, 2018; Enduri & Jolad, 2018). Mechanisms through which migration and mobility influence disease diffusion have been widely studied (Changruenngam et al., 2020). Mathematical modeling has been used to understand how diseases diffuse within geographical locations and the role that human mobility plays in this process (Liu & Xiao, 2013; Hethcote, 2000).

Africa presents unique geomedical problems of interest to medical geographers, and the range of diseases encountered in the continent varies widely. These include the unique "tropical" diseases that are endemic to the continent, including malaria, sleeping sickness, and schistosomiasis, amongst others (Prothero, 1981). Pandemics occur when infectious diseases spread rapidly to many people, causing major health and livelihood challenges globally. The Ebola virus disease outbreak in West Africa in 2014–2016 and the recent COVID-19 outbreak globally are two pandemics that have occurred globally. Epidemics occur, when a disease affects a large number of people within a localized setting such as a community, population, or region. Between 2003 and 2007, the most common epidemic outbreaks in Africa included cholera, dysentery, malaria, and hemorrhagic fevers such as Ebola, Rift Valley fever, and yellow fever (Kebede et al., 2010), while during the 2016–2018 period, the outbreaks included malaria, cholera, viral hemorrhagic diseases, measles, and meningitis (Mboussou et al., 2019; WHO, 2018).

An emerging area of interest has been the role that human mobility plays in the diffusion of infectious diseases. Few scholars outside Nigeria had published articles on medical geography hitherto; thus, when Prothero (1981) compiled a set of research articles on medical geography in Africa, he observed that many of the scholars were from Nigeria, "a country with a greater number of universities than any other in Africa, in which geography flourishes, with many geographers whose work is known internationally" (Prothero, 1981: 4). Prothero has made immense contributions to medical geography including the nexus between population mobility and diffusion of malaria (Prothero, 1961, 1963) and sleeping sickness, in Nigeria. He has also published on the spread of HIV/AIDS in West Africa (Prothero, 1996) and in the thematic study of health and medical geography (Prothero, 1981). Prothero's work has influenced the global discourse on the role that migration plays on disease transmission (Prothero, 1977, 1989, 1994, 2002), including risk of malaria transmission from Africa to Europe (Prothero, 2002), and the role that the tropical climate plays in sustaining waterborne diseases in Africa (Prothero, 2000).

Several studies have investigated the spatial spread of HIV/AIDS in Africa and the role that human migration and mobility played in transmission of the virus (Faria et al., 2014; Amat-Roze, 1993; Cliff & Smallman-Raynor, 1992; Quinn, 1994; Wood, 1988). Some studies find that the spread of HIV in the East African region differed from that in the West and North African region (Gray et al., 2009; Mokili & Korber, 2005). Reasons given for the geographical variation include the fact that there is higher connectivity between population centers in East Africa since colonial times, compared to central Africa, such as the Democratic Republic of Congo (Gray et al., 2009). Fewer studies investigated the spatial spread of HIV in the East African region, although regional studies, on sub-Saharan Africa, indicated a higher proportion of urban-based cases of HIV in specific East African countries (Voeten et al., 2010; Dyson, 2003; Caldwell et al., 1989) and the higher prevalence in East Africa compared to other parts of Africa (Caldwell, 2006).

Ebola has affected the African continent severally since 1976. The largest outbreak of Ebola in Africa was reported in West Africa, between March 2014 and June 2016, affecting several countries including Guinea, Liberia, and Sierra Leone, where over 28,000 cases were reported (WHO, 2016). Analysis of the spatial spread of the West Africa Ebola epidemic shows that the spread of the Ebola Virus was strongly affected by human mobility across Guinea, Liberia, Sierra Leone, and other neighboring countries (Kramer et al., 2016). The outbreak also occurred in urban areas, for the first time, while previous episodes were reported in remote areas and where population density was low (Alexander et al., 2015). There have been several outbreaks in Uganda, which borders the Democratic Republic of Congo, and one incident, where the Ebola virus has been reported in Rwanda. Ebola has not affected other countries in East Africa, despite the close connectivity with Uganda.

From the emerging review, the HIV/AIDS burden in East Africa is higher than most regions in sub-Saharan Africa. Moreover, the higher prevalence in urban areas compared to rural areas points to linkages with mobility. While the East African region has not borne the brunt of the Ebola virus, there have been few incidents reported in Uganda, while none have been documented in Kenya or Tanzania. The COVID-19 pandemic has not had devastating effects in the East African region, but the role that global travel played in spreading the disease to the EAC region confirms the close nexus between human mobility and disease transmission.

It is against this backdrop that the current chapter revisits the role that human mobility and migration play in disease diffusion with particular focus on the East African Community (EAC) region, comparing the spread of HIV, Ebola, and the recent COVID-19 pandemic. The work investigates the diffusion and transmission of the coronavirus disease in EAC, comparing this to the trajectory of HIV/AIDS and Ebola.

7.3 Data and Methods

This study examined the linkages between spatial mobility and diffusion of HIV/AIDS, Ebola, and COVID-19 in the East African region. This was done through a review of published articles on the origins and spread of these diseases in the East African region between 1980–2020 factoring the spread of HIV in the region in 1980s and the emergence of the novel coronavirus disease, COVID-19 in 2019, and in East Africa in 2020. Research articles were identified using two online search engines, PubMed and Google Scholar, and subjected to a critical review to identify linkages between human mobility and the diffusion of the respective diseases, namely, Ebola, COVID-19, and HIV/AIDS, in the EAC region as a whole or within the respective member states, namely, Burundi, Kenya, Rwanda, Sudan, Tanzania, and Uganda.

7.4 Results

7.4.1 Mobility and Diffusion of HIV/AIDS in East Africa

HIV/AIDS was first detected globally in 1981, and the first case in sub-Saharan Africa was reported in Uganda in 1982, in Rakai District in the southwestern part of the country, amongst a fishing community (Lubega et al., 2015; Mugyenyi, 2002; Serwadda et al., 1985). The disease, previously known as "slim disease" owing to the symptoms associated with it, presented features similar to those seen in neighboring Zaire, now Democratic Republic of Congo (Serwadda et al., 1985), and although the epicenter was Uganda, it would later spread beyond borders to the other East African countries (Seeley et al., 2010). Data from the HIV Sentinel

Surveillance showed that by 1999, four million people were living with HIV in sub-Saharan Africa (which had been hardest hit by the virus), majority of whom were women. The common mode of HIV transmission in Africa was heterosexual transmission (WHO, 2000).

Following the reports of HIV in Uganda and other regions of the worlds, the World Health Organization (WHO) set up a surveillance system to enable the tracking and monitoring of HIV/AIDS, using data obtained from women attending antenatal care clinics, patients visiting hospitals from treatment, and behavioral surveillance in communities with high prevalence of HIV (WHO, 2000). Geographical modeling of HIV in Africa gained prominence thereafter, following a UNAIDS meeting that called for the generation of granular data on the geographical spread of HIV within countries, so as to inform suitably targeted interventions (UNAIDS, 2007).

HIV had a higher prevalence in East Africa compared to developed countries, although the incidences were predominantly higher in urban areas (Mhalu & Lyamuya, 1996; WHO, 2000). In the Rakai District in Southwest Uganda, for example, where the first case of HIV was recorded, higher prevalence was found in the roadside trading areas and smaller trading areas within secondary road networks in the rural setting, while the rural agricultural villages had lower prevalence, but the men reported higher prevalence than women (Wawer et al., 1991). This led to scholarly interest to establish the underlying factors for this phenomenon. The linkages between spread of HIV and human mobility and migration emerged when the prevalence rates were correlated with social factors. Anthropologists like Caldwell investigated the social contexts of HIV in sub-Saharan Africa and concluded that high-risky sexual behavior amongst urban migrants was driving the higher HIV prevalence rates in urban areas within countries (Caldwell et al., 1989). This would be confirmed in several follow-up studies in Burundi (Barankanira et al., 2015), Kenya (Brockerhoff & Biddlecom, 1999), Uganda (Hudson et al., 1988), Tanzania (Barongo et al., 1992), and Rwanda (Allen et al., 1991). One of the high-risk groups emerging from the research on spread of HIV are the long-distance truck drivers, who contributed to the spread of HIV in urban areas, where they sojourned as they transported goods across the East African region (Morris & Ferguson, 2006; Bwayo et al., 1991).

Following the observations of the risky behavior of migrants and increase in HIV prevalence, the World Health Organization (WHO) commissioned a study in 1992, to determine the root causes of this phenomenon. What was puzzling at the time was the high susceptibility of HIV in sub-Saharan Africa compared to Northern Africa and other parts of the world (Caldwell & Caldwell, 1996). Understanding why the patterns were prevalent in Africa, especially East Africa, compared to other parts, involved a series of social studies. Hunter (1993) in his study of the AIDS epidemic in sub-Saharan Africa concluded that sexual behavior determined the spread of HIV within countries, especially through sexual networks. Thus, female sex workers and their male clients were at a high risk of infection, while men with multiple sexual partners contributed to the spread of HIV to women in the general population. Coupled with the risky sexual behavior were the presence of sexually transmitted diseases and lack of male circumcision, which could increase the odds of transmission of HIV during sexual intercourse. Hunter (1993) further posits that the fast pace of urbanization in Africa resulted in higher rural to urban migration, and the young men moving to urban areas in search of work would later engage in risky behavior. These findings were later corroborated by Caldwell and Caldwell (1996) showing that urban migrants who were predominantly young males would leave their wives and family in the village to seek labor in urbanized settings to earn income to pay for taxes. The young men would engage in extramarital sexual relations usually with little or no protection. On the other hand, the wives and women left in the villages would engage in "prostitution" or other extramarital relations with the men in the villages, exposing them to risk of sexually transmitted diseases including HIV/AIDS. Through this cycle of risky behavior, there were higher prevalence of HIV amongst men in urban areas and women in rural areas.

The interest in sexual networks and their role in HIV diffusion provided evidence on the role that migration plays in diffusion of HIV. Migration, especially from rural areas to urban areas, resulted in adoption of new liberal behaviors outside the cultural contexts, resulting in heightened risky behavior especially amongst men than women especially those in marital unions. In some cases, over half the men and more than one-quarter of women identified lifetime sexual relations with ten or more persons (Orubuloye et al., 1992). The heterosexual transmission of the disease in Africa was starkly different from the association with the gay community in the West (Seeley et al., 2010). However, it was recognized that while sexual networking was an important factor for the high rates of HIV, other structural factors may be at play, including health sector deficiencies (Mugyenyi, 2002). In Uganda, for example, while infection rates were higher for the older persons, it is disproportionately higher amongst uncircumcised ones (Opio et al., 2013). Migration of men and women would account for the spread of HIV in East Africa differently, with higher prevalence amongst men in urban areas, while women had lower prevalence (Ngesa et al., 2014; Johnson & Way, 2006).

The effect of migration on the spread of HIV is temporally limited, as research shows that it is higher at the onset of the pandemic, but wanes over time. This was confirmed in a study comparing the effect of migration on the spread of HIV in 28 countries in sub-Saharan Africa, where the HIV prevalence patterns between men and women and respective in-migration rates to urban areas, were compared (Cuadros & Abu-Raddad, 2014). The findings show a strong association between HIV prevalence and in-migration of women in urban areas in the earliest phase of the pandemic (1985–1994), which wanes in the next phase (1995–1999) and becomes insignificant in the year 2000. With the use of spatial maps, further evidence of the spatial variations in HIV prevalence are revealed (Cuadros et al., 2017; Sia et al., 2014; Cuadros & Abu-Raddad, 2014; Cuadros et al., 2013; Seeley et al., 2010; Montana et al., 2007). The patterns revealed spatial variations in prevalence rates within and between countries.

Cuadros et al. (2017) mapped the HIV prevalence in East Africa, using DHS data for 2008–2009 for Kenya, 2010 for Malawi, and 2011–2012 for Tanzania. We illustrate these spatial variations in Fig. 7.2, where two countries from the EAC – Kenya

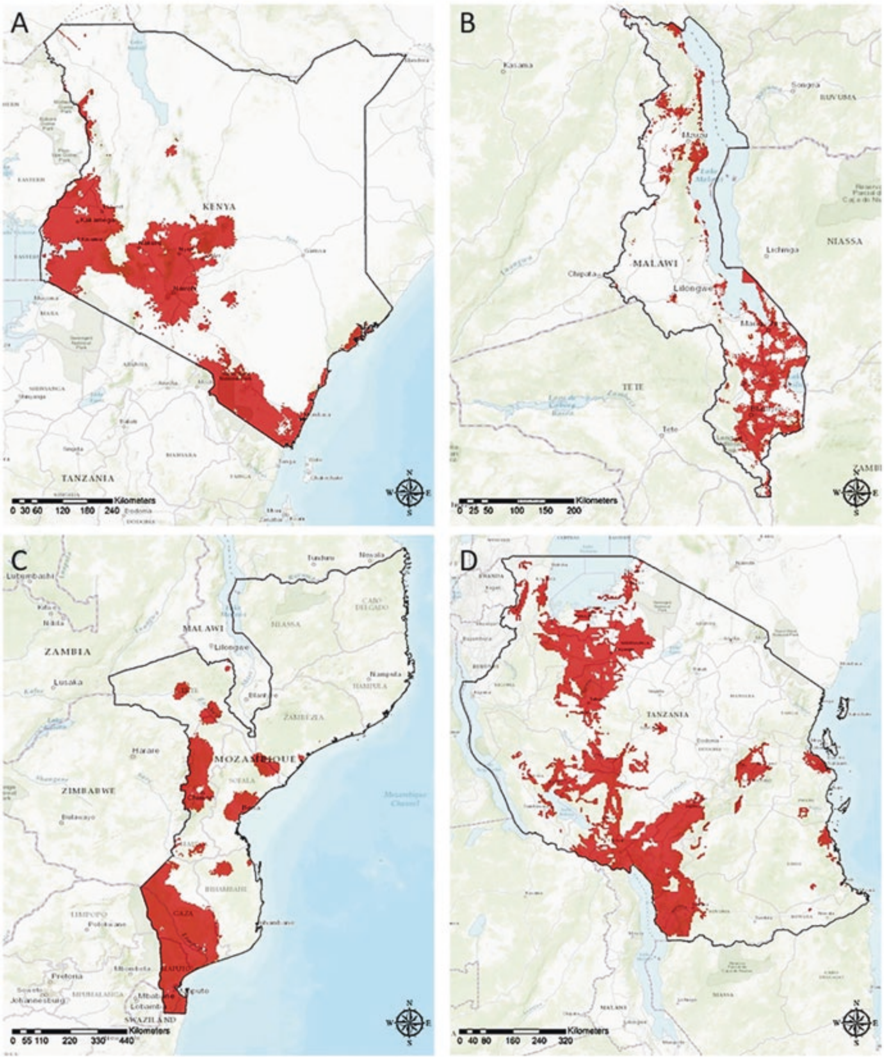

Fig. 7.2 Areas with high HIV prevalence in Kenya, Malawi, Mozambique, and Tanzania. (Source: Cuadros et al. (2017))

and Tanzania – are featured. For Kenya (see Frame A), there is evidence of clustering in several locations including the Lake Victoria Basin, and in the central part of the country regions bordering the capital city of Nairobi, including Nakuru, Nyeri, and Central Kenya counties, and in the southern part of the country bordering Tanzania, along the Namanga border point, as well as the coastal strip, where Mombasa, the second largest city, is located. In Tanzania (Frame D), the map reveals clustering of HIV prevalence in the western part of the country neighboring Rwanda and Uganda, to the northwest, and the region surrounding Lake Victoria basin, with a southern strip toward the border with Malawi, especially in Mbeya, Tunduma, Njombe, and Songea towns. There are clusters of high prevalence located along the coastal strips especially in Dar es Salaam, the former capital city of Tanzania and Mtwara and Lindi towns along the coast, and in Dodoma, the capital city of the United Republic of Tanzania.

The results of the analysis show that prevalence rates of HIV are still high in the EAC region, with spatial variations within countries. Reducing the prevalence rates will be challenging as there is high mobility in the region, with increased flows owing to the Free Movement of Persons Protocol and EAC regional integration agenda. The challenge of HIV is that the prevalence is a complex interaction between incidence, mortality, and migration patterns (Dwyer-Lindgren et al., 2019).

The emergent findings from the review of the spread of HIV in East Africa confirm the catalytic role that human mobility/migration plays in the diffusion of the disease, albeit in the earlier phase of the pandemic. Prevalence of HIV is reportedly higher in the urbanized areas compared to rural areas, with the behavior of migrants playing a critical role in the spread of HIV, in light of the heterosexual mode of transmission. While gendered outcomes are reported, such as women having higher infection in rural areas, compared to males, the underlying cause of the surge in HIV cases was through the interrelations between infected and uninfected persons in such spaces.

A notable observation was the high prevalence of HIV along the Lake Victoria basin, for all the EAC member states, prompting researchers to study the communities living along Lake Victoria to understand the root causes for the higher prevalence (Kwena et al., 2019; Opio et al., 2013; Kiwanuka et al., 2013; Seeley et al., 2012; Nunan, 2010). Suggestions from the research point to the risky sexual behaviors amongst the fisherfolk, such as "sex-for-fish," the practice where women traders have casual sex with the fishermen in order to get fish stock to sale at the local market, thus identifying the fisherfolk as a high-risk community for HIV, similar to the commercial sex workers. This observation resulted in behavior change interventions for communities at the lakeside.

7.4.2 Mobility and Diffusion of Ebola in East Africa

Ebola virus disease, commonly known as "Ebola," was first identified on the African continent in 1976 in two countries: the Sudan and the Republic of the Zaire Congo, presently Democratic Republic of Congo (WHO, 2021). The disease is believed to have originated from the Central African rainforest and is caused by the Ebola virus affecting human beings and other primates (Chippaux, 2014).There are six species of the virus with the names associated with the geographical regions where they first manifested, *Zaire ebolavirus*, *Sudan ebolavirus*, *Tai Forest ebolavirus* in Cote d'Ivoire, *Bundibugyo ebolavirus* in Uganda, *Reston ebolavirus*, and *Bombali ebolavirus* (Mukadi-Bamuleka, et al., 2022). Ebola disease is transmitted from human to human; hence mobile populations play a key role in the cross-border transmission of the disease. Several studies document how Ebola virus is transmitted from person to person, for example, in Sudan (Baron et al., 1983), Gabon (Ivanoff et al., 1982), and Central African Republic (Johnson et al., 1993). Human transmission is only fatal if there is exchange of blood or secretions from infected persons (Chippaux, 2014). Since Ebola virus disease is transmitted by close contact with body fluids from victims, managing the human transmission involves contact tracing and safe burial of the deceased. The transmission of Ebola virus has been characterized by predominance in rural communities and amongst densely populated peri-urban centers, as well as in regions sharing borders with disease hotspots and in transmission in healthcare settings where treatment of patients occurs (WHO, 2018).

The East African region has been classified as having a low risk of an Ebola outbreak, but Uganda and Rwanda have been affected by outbreaks of the disease in the past. While Kenya, Burundi, and Tanzania have no recorded cases, public health systems have been on preparedness mode owing to possible cross-border transmission from Uganda, due to the free movement of people across the East African Community. Two countries in East Africa have been affected by Ebola, namely, Uganda (several waves of the Ebola) and South Sudan. The spread of the virus in Uganda and South Sudan could be traced to cross-border infections from the Democratic Republic of Congo, into Uganda, Sudan, and Rwanda.

The first case of Ebola in the EAC region was reported in 1976 in The Sudan, in the region that is present day Southern Sudan, and traced to two areas, Nzara and Yambio, located at the Southern Sudan border with present day Democratic Republic of Congo. The initial outbreak was accompanied by secondary outbreaks in Maridi, Tembura, and Juba Districts (Ivanoff et al., 1982; Chippaux, 2014). The next outbreak of Ebola was reported in Uganda, in 2000, in Gulu District, which borders South Sudan. The Ebola species in Uganda in 2000 was identified as *Sudan ebolavirus*, and a total of 425 cases were reported with a fatality of 224 deaths, translating to a case fatality rate of 53% (Okware et al., 2002). The majority of the cases originated from Rwot-Obillo, a remote village 14 km north of Gulu town, where 12 people had died, including a healthcare worker and 2 student nurses; thus linkages are made to those attending burial ceremonies of the deceased (Gonzalez et al., 2005; Morvan et al., 2000). The virus would persist till 2001, affecting additional districts of Mbarara and Masindi (Chippaux, 2014; Borchert et al., 2011). A study that traced the spread of the disease from Gulu to the rest of the country, in the 2011 outbreak, suggests that an infected healthcare worker from a hospital in Gulu, returning home to Masindi, would later transmit the virus to her index family members, and the infection would increase to other extended networks of the index family to Mbarara District (Borchert et al., 2011:2). A second outbreak of Ebola occurred in Uganda in 2007, in the Bundibugyo region in the Western Region of Uganda, bordering the Democratic Republic of Congo, and the species was identified as *Bundibugyo ebolavirus.* In the third wave of Ebola in Uganda, the incidence was still located in Bundibugyo town, bordering the Democratic Republic of Congo, and later in Kikyo town, also in Western Uganda (WHO, 2011). The fourth outbreak was reported in Luwero, Kibaale, and Kampala, in 2012, and corresponded to an outbreak of the same virus in the neighboring Democratic Republic of Congo

(WHO, 2021; Chippaux, 2014; Mbonye et al., 2014). This fourth outbreak was contained within six weeks, following intensive contact tracing and quarantine (Okware, 2016).

Rwanda experienced an Ebola outbreak in 2019, following a corresponding major outbreak of the Ebola virus in Goma, in 2018, in the Democratic Republic of Congo (Tuite et al., 2019). The 2019 Ebola outbreak also affected Uganda (Schuh et al., 2021). Okware (2016) provides a spatial map generated from WHO Health Mapper software that illustrates the spread of Ebola virus in Uganda during the different waves (see Fig. 7.2). Cross-border mobility between Democratic Republic of Congo, Rwanda, and Uganda contributed to the transmission of the disease, owing to trade and regional relations between these countries (Nakiire et al., 2020; Tuite et al., 2019). Goma is a major transit hub located in the Western border with Rwanda and attracts high population mobility from regular migrants and forced migrants like refugees – Congo refugees who had moved to Uganda and Rwanda following civil unrest in Democratic Republic of Congo and Rwandese refugees in Uganda following the 1994 genocide in Rwanda, as well as Rwandese returnees from Congo (Ahimbisibwe, 2019; Nakiire et al., 2020).

Uganda has reported the highest number of Ebola outbreaks in the EAC region (Fig. 7.3), probably due to the proximity with the Democratic Republic of Congo, where several outbreaks have also occurred. Following the formal border closures between the Democratic Republic of Congo, Rwanda, and Uganda, after the 2019 Ebola outbreak, the terrestrial routes used by citizens to move across the three countries shifted. Officials from Uganda who conducted a population connectivity mapping exercise to determine if population movements were still occurring despite the containment measures, established that people were using alternative irregular routes, along the Uganda-Democratic Republic of Congo border, to move between the two countries, where they avoided the border security screening systems (Nakiire et al., 2020).

Despite Ebola having a limited spread in the East African region, lessons in management and transmission learned from West Africa where the outbreak has been more prevalent (Affara et al., 2021) were applied in the management of the outbreaks.

7.4.3 Mobility and Diffusion of COVID-19 in East Africa

The novel coronavirus, also known as COVID-19, emerged in Wuhan, China, in December 2019, and spread globally, with human mobility playing a key role in this spread (Benton et al., 2021; de Bruin et al., 2020). The first cases in Africa were reported in February 2020, in Egypt and then Nigeria. COVID-19 would eventually be reported in the East African region in March 2020, with confirmed cases reported in Burundi (Habonimana et al., 2020; Manirambona et al., 2021), Kenya (Republic of Kenya, Ministry of Health, 2020b), Rwanda (Musanabaganwa et al., 2021), Tanzania (Tarimo & Wu, 2020), and Uganda (Olum & Bongomin, 2020) as

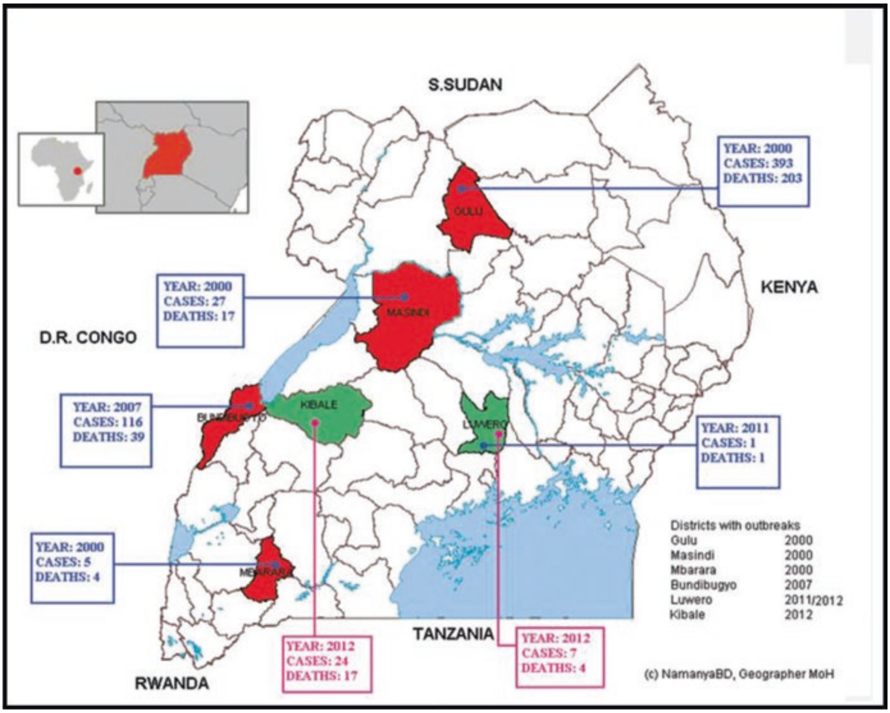

Fig. 7.3 Outbreaks of Ebola in Uganda by district, 2000–2012. (Source: Okware, 2016:5)

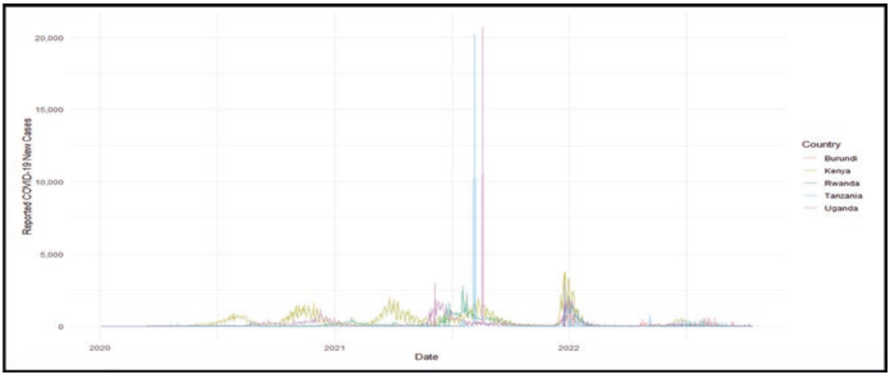

Fig. 7.4 COVID-19 incidence counts, EAC 2020–2022. (Source: Authors)

illustrated in Fig. 7.4. While COVID-19 cases were high globally, North and West Africa reported higher cases than the East Africa, with Burundi and Uganda reporting some of the lowest incidence rates regionally (Gayawan et al., 2020). Some of the containment measures include lockdown of major cities and global airspace, as well as public health measures like wearing of face masks, social distancing, and quarantine of infected persons.

The first cases of COVID-19 in the EAC region were reported from persons with travel history, confirming the role that human mobility played in transmission of the virus globally. In Burundi, the first two cases were nationals returning to the country, one from Rwanda and the other from the United States (Tasamba, 2020). In Kenya, the first reported case was a traveler returning from the United States (Ministry of Health, 2020), while in Tanzania, the first case was a traveler from Belgium through the Arusha International Airport in Tanzania (Mumbu & Hugo, 2020; Tarimo & Wu, 2020). The first case reported in Uganda was a traveler from Dubai, United Arab Emirates, who was returning home through the Entebbe International Airport (Olum & Bongomin, 2020). From these initial cases, the diffusion on COVID-19 to the larger population was mostly through human transmission, as the virus is highly transmissible through close contact with an infected person through coughing, sneezing, breathing, or even talking that results in saliva droplets falling on the noninfected persons.

Tracking of the spread of COVID-19 in the East African region reveals a mixed scenario, with Burundi and Tanzania stopping the tracking of cases, owing to political reasons, while Uganda, Rwanda, and Kenya continued with monitoring the counts. As a result, online data for COVID-19 cases for Burundi and Tanzania for the first few months of COVID-19 remain scanty. There were two distinct waves of COVID-19 in Kenya in the first year, 2020, in August and mid-November, and a third wave in March 2021 with the highest infections reported in the two largest cities, Nairobi and Mombasa, which were placed under lockdown and strict public health measures. Comparatively, Uganda also experienced two waves of COVID-19 in March–April and later in May 2020. The Uganda government reported that the highest number of COVID-19 cases, up to 89%, were imported to the country, half of this number attributed to infections by truck drivers, mainly from Kenya and Tanzania (Olum & Bongomin, 2020; Bajunirwe et al., 2020).

For Kenya, where data is available, one can observe that the COVID-19 prevalence rates mirror the migration and mobility patterns in the country; see Figs. 7.5 and 7.6, respectively. The Ministry of Health in Kenya tracked the COVID-19 cases and provided daily updates on the status of COVID-19 in Kenya using the Daily Situation Reports (SITREPS). Figure 7.5 presents the mapping of COVID-19 cases in Kenya as reported on 30th June 2020, by the Ministry of Health. The subnational units/counties with the largest number of cases include Nairobi, the capital city, and the neighboring counties of Kiambu, Nyeri, Nakuru. Kajiado County where the Kenya-Tanzania border point, Namanga, is located also had high cases of COVID-19. Toward the eastern and coastal parts of the country, the figure shows high COVID-19 prevalence in several counties which host large urbanized areas including Machakos, Kitui, Taita Taveta, and Mombasa County which hosts the second largest city in Kenya. To the western part of the country, higher COVID-19 cases are evident in all the major urbanized counties including Busia, along the border with Uganda, Uasin Gishu, Kisumu, and Migori (along the border with Tanzania), and in the administrative headquarters of the northern frontier counties.

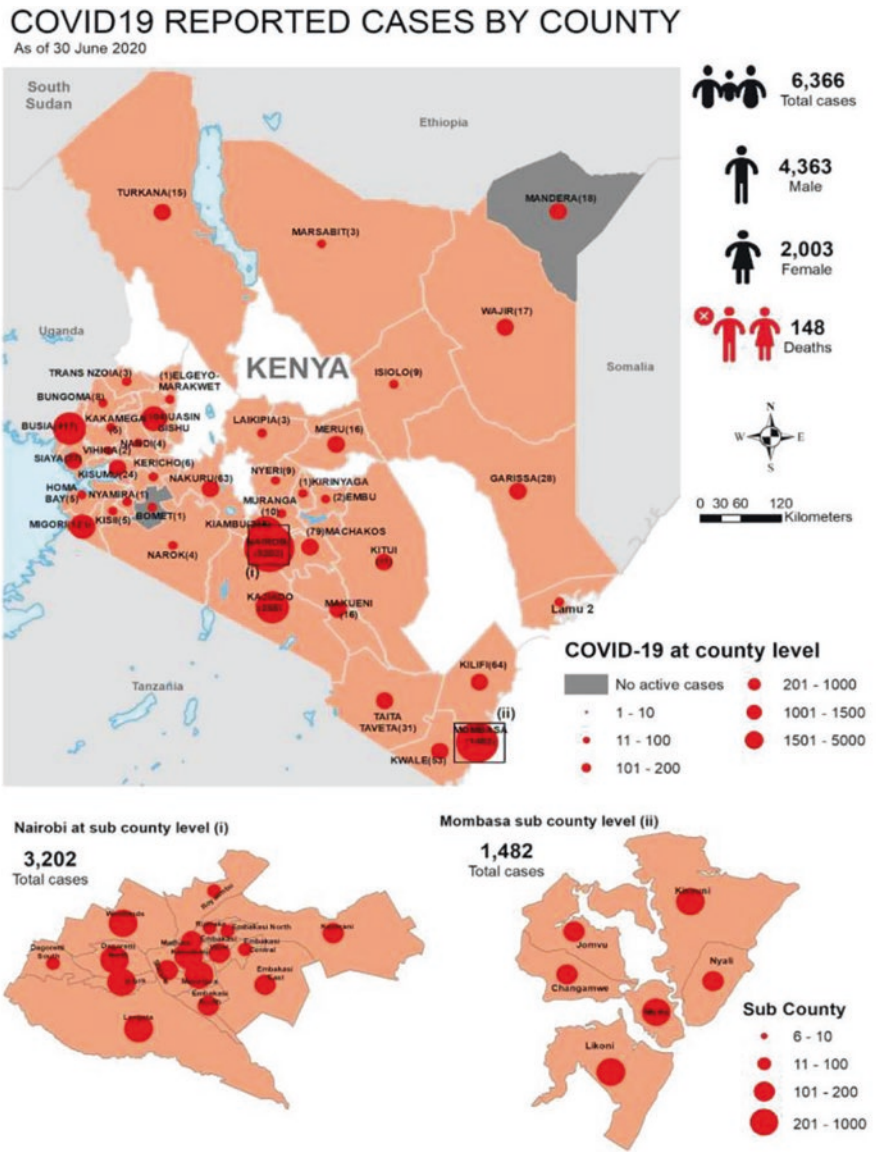

Fig. 7.5 Mapping of daily COVID-19 cases by county, Ministry of Health Daily Situation Report No. 105 for 30 June 2020. (Source: Republic of Kenya, Ministry of Health (2020b))

The June 2020 SITREP highlights the diffusion of COVID-19 in the country that mirrors the urbanization and migration patterns in the country (Republic of Kenya, 2020a). Initially, the first case of COVID-19 in the country was identified in Nairobi, from an international traveler, a returnee. Thereafter, the number of cases spread out toward the counties. As per the SITREP report from the Ministry of Health, the top

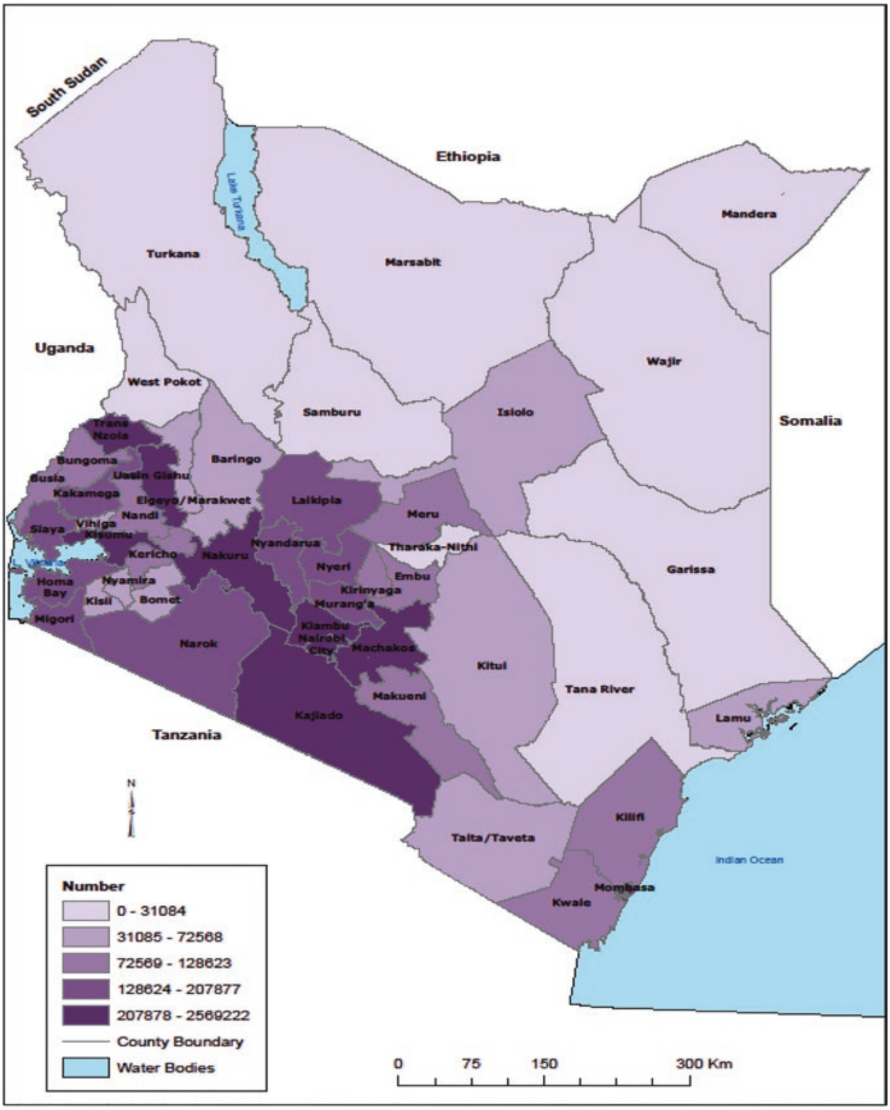

Fig. 7.6 Spatial distribution of lifetime in migrants by County, 2019. (Source KNBS (2022))

counties with new cases were Nairobi, Mombasa, Kiambu, Migori, Uasin Gishu, Busia, Kajiado, Kilifi, Kakamega, Kisumu, Machakos, and Narok. Out of these 12 counties are the three largest cities in Kenya – Nairobi, Mombasa, and Kisumu – as well as those contiguous to them like Kiambu, Machakos counties that border Nairobi, and Kilifi County which borders Mombasa. Prevalence was high in counties located along the international borders including Busia, Kajiado, Narok, and Migori.

The internal diffusion of COVID-19 in Kenya mirrors the internal migration pattern in the country as elaborated in earlier works, where influx of migrants is higher in areas with higher urbanized settlements including Nairobi, Nakuru, Kiambu, Mombasa, and Kisumu counties, in secondary urban areas in 2009, including Kajiado, Machakos, Kilifi, Meru, and Busia counties (Muyonga et al., 2021). The observations are made in the 2019 population census migration data; see Fig. 7.6 where the darker colors capture the regions with higher migration and mobility in Kenya.

The rise in COVID-19 cases in the East African Community reflected a hierarchical diffusion pattern, where the epicenter of the pandemic was in the capital cities, accounted for by the presence of international airports and higher population density, and later spread outward to secondary cities and to rural areas. The illustration of Kenya confirms this, and as a result, the first lockdown measures were effected in the major urbanized areas of Nairobi and Mombasa, which are the two largest cities in Kenya (Brand et al., 2021). In Uganda, the first cases of COVID-19 were imported cases from international travelers mainly from the United Arab Emirates and United Kingdom (Migisha et al., 2020). The distribution of COVID-19 cases in the East African countries confirms this observation and concurs with previous research on the migratory trends in some of the countries, for example, the pattern of spread of COVID-19 in Kenya is similar to the destinations including the capital city and in counties along international borders (Muyonga et al., 2021).

A notable surge in COVID-19 cases was observed when the lockdown measures were relaxed in several countries, and the population mixing may largely account for the increase in transmission rates during this time (Brand et al., 2021). Thus, human mobility played a catalytical role in the spread of COVID-19 in the East African region and elsewhere, and the effects waned when population movements were restricted as part of the COVID-19 emergency response protocols. The same observations were made in China, the epicenter of COVID-19 globally, where the population emigrating from Wuhan was the source of infection in other cities and provinces in China, such that the lockdown of cities in the epicenter of the pandemic, resulted in the reduction in the spread of positive cases in China (Hu et al., 2021; Chen et al., 2020). The lockdown measures were effective barriers to the geographical spread of COVID-19, because they affected the structural mobility networks – by reducing long-distance travel, hence localizing mobility and the resultant social networks, and cutting off connections with geographically distant regions (Schlosser et al., 2020).

Understanding the modes of transmission of infectious diseases coupled with the factors influencing the spatial spread is the key requirement for the effective management of the disease outbreaks. Improvements in technology have largely improved the tracing of disease outbreaks globally. Adoption of such methodologies in response efforts in Africa will improve the management of future epidemics. Mapping of the spread of COVID-19 has been facilitated by the use of GIS technology that enabled modeling of the spread of the virus in Africa (Babalola, 2020; Franch-Pardo et al., 2020). Oyedotun (2021) provides a good review of application of geographical techniques in COVID-19 research.

This study focused on the East African region and relied on secondary data. While efforts were made to capture information on COVID-19 that affected all the countries, there was scanty evidence on the incidence of COVID-19 in Tanzania for the first few months of the pandemic. Additionally, the study was conducted before the Democratic Republic of Congo joined the EAC bloc, and therefore little focus was given to DRC and South Sudan in this review.

7.5 Conclusion

The East African region, especially Kenya, Tanzania, and Uganda, has been faced with several major epidemics that affected the health and livelihoods of the population including HIV/AIDS, Ebola virus disease, and COVID-19. Human spatial mobility is associated with diffusion of infectious diseases, as human beings carry pathogens as they move from place to place, therefore spreading diseases to the new regions they move to. This chapter undertook a historical review of the spread of the diseases of these diseases in the East African region for the period 1980–2020 using available literature. The extended time frame enabled us to review the incidence of HIV/AIDS and Ebola in the region and the more recent incidence of COVID-19 in 2020.

Human mobility influences the temporal and spatial spread and transmission of infectious diseases. First, migration and human mobility link geographically separate areas when infected person(s) move the disease to new areas or encounter new diseases when they move to new places. Spatial heterogeneity related to travel has implications on disease diffusion as demonstrated in the rapid spread of COVID-19 from China, the SARS epidemic in China in 2003, and swine flu in 2009 (Khatua et al., 2020). Second, through the behavioral characteristics of migrants, human mobility may increase their susceptibility to certain diseases, such as the risky sexual behavior and the spread of HIV in sub-Saharan Africa (Deane et al., 2010; Caldwell et al., 1989). This study confirms that transmission of COVID-19, Ebola, and HIV was facilitated by population mobility, resulting in the spread of these diseases from high infection to noninfected geographical regions as confirmed elsewhere (Fortaleza et al., 2021; Cos et al., 2020). Human mobility led to increased spread of COVID-19, HIV, and Ebola, owing to the modes of transmissions. The transmission of COVID-19 is through close contact with an infected person through coughing, sneezing, breathing, or even talking that results in saliva droplets falling on the noninfected persons, while Ebola virus is transmitted by direct contact with blood, secretions, organs, or other body fluids of infected persons. Additionally, HIV is transmitted through direct contact with blood, secretions, or body fluids of an infected person (Briand et al., 2014; Rewar & Mirdha, 2014; WHO, 2014).

The infectious disease hypothesis argues that infectious diseases are spread fastest when populations are mobile; in-migrants can bring new diseases to the host population and acquire new diseases from an infected host population. In the early phase, disease outbreaks may be difficult to recognize as human mobility results in diffusion of the disease across a given population (Rogerson & Han, 2002); however, as the disease spread geographically, the patterns of the spread emerge confirming other hotspots located in other sites away from the original epicenter (Sirkeci & Yucesahin, 2020; Dalvi & Braga, 2019; Nepal, 2002; Rosenberg, 1998). This is confirmed in the case of COVID-19 in East Africa where urban cities were the main epicenters of the disease (Alhassan et al., 2021) and the resultant control measures were lockdown of the capital cities. Comparatively, owing to the nature of the spread of Ebola, the disease diffused from high prevalence areas largely connected to the epicenter in the Democratic Republic of Congo to low prevalence areas in the neighboring countries. HIV demonstrated a similar pattern of urban-rural differentials, but there has been higher prevalence in urban regions, associated with risky sexual behavior amongst migrants and mobile populations, while the disease spread to the periphery owing to long-distance truck drivers and return migrants, to their rural origins. What remains unknown is why HIV prevalence is higher amongst the communities in the Lake Victoria basin.

The medical geography approach provides a useful lens for understanding not only how diseases are spread but also outlining some of the behavioral, ecological, and structural factors that explain why diseases occur in certain areas and not others. In the case of HIV, several factors interplay resulting in the observed rates such as cultural factors like the sexual relations and behaviors within the communities, the lack of awareness of HIV, and status of health infrastructure, amongst others (Opio et al., 2013). Thus, while the geographical distribution of the disease gives an indication of where the hotspots or cold spots are, applying other social and economic models helps to unpack the root causes of the spatial variations, resulting in a better picture of the diffusion of the disease. Apart from the geographical visualization of the spread of diseases, modeling the linkages between spread of the disease across space and time can unveil unique features of the nexus between human mobility and diffusion of diseases. In Germany, for example, a study found that hierarchical diffusion was absent, and the surge in COVID-19 was largely attributed to tourist returnees; hence relocation diffusion was the main method of transmission of the virus across the population (Kuebart & Stabler, 2020) in contrast to East Africa, where majority of cases of COVID-19 were from contagious infections from the original returnees owing to population mobility between contacts of those initially infected.

Infectious diseases cause a devastating effect on societies as they are quickly spread across the population leading to huge strain on healthcare infrastructure. Managing the spread of such diseases becomes a public health priority, so as to reduce the social and economic strains on the wider community. Improvements in health can catalyze development as a healthy population can work and build the nation. Thus, understanding how human mobility catalyzes the spread of such diseases can help in the design of suitable intervention public health intervention measures such as the movement restrictions witnessed during the COVID-19 pandemics. There are other structural and environmental factors which may explain why such diseases remain prevalent in certain geographic locations or amongst certain population groups, and applying a multidisciplinary approach to understanding disease diffusion helps in designing a comprehensive response plan. There is an added advantage to using geospatial technology in understanding the linkages between migration and disease diffusion in Africa to improve understanding on how diseases spread and the critical factors influencing this within this geopolitical region.

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Chapter 8
Management and Prevention of HIV Infection in Migrant Miners in Lesotho and South Africa: A Capabilities Approach

Esther Nako, Lochner Marais, and Michelle Engelbrecht

8.1 Introduction

Migrant health concerns are a global problem, and the increase in migrants globally will require an appropriate response. Migration affects health, and many host countries exclude migrants from health services or struggle to address their health needs (Lurie & Stuckler, 2010). Consequently, migrants often have unaddressed health problems.

South African mines have employed many migrant workers from neighbouring countries, including Lesotho, over the past 70 years. In the mid-1980s, approximately 120,000 men from Lesotho worked in South African mines (Crush et al., 2005), mostly in the Free State Goldfields, about 200 km from the border between the two countries. The decline of the gold mining industry, technological improvements and changing recruitment practices have reduced the number of mining jobs since the early 1990s. Migrant work has had social and health implications, with HIV/AIDS being the most prominent (Lurie et al., 2003; Crush et al., 2005). HIV/AIDS is closely associated with institutionalised migrant labour and living in single-sex compounds (Rajak, 2010). By the early 2000s, most of the compounds had been dismantled, labour contracts had changed, the scale of migration had declined and there was less restriction on movement. Research has been done on the social aspects of HIV (e.g. Catalán et al. (1997)), and there have been substantial developments in research taking a capabilities approach to health (Anand, 2005; Venkatapuram, 2013), but the topic of migrant workers' capabilities to manage HIV

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remains under-researched. The mining industry responded with HIV management and prevention programmes in the early 2000s (Rajak, 2010). There were clear economic benefits for mining companies: improved productivity, fewer sick days for their employees and a lower turnover of staff. These programmes assume that the mines will solve the problem by paying for antiretroviral treatment and making it available to their employees.

Despite the positive steps by the mining companies, several questions remain: how do migrants experience the service, what obstacles does migration present to accessing the service and how do migrants use the service? We use the capabilities approach to investigate the factors constraining the development of migrants' capabilities to manage or prevent HIV infection.

8.2 The Migration and Health Literature and the Capabilities Approach

8.2.1 Migration and Health

The scale of migration has increased globally over the past 50 years, with 75 million migrants in 1965 increasing to 258 million in 2017 (United Nations, 2017). The link between migration and health problems is well established (Lurie & Stuckler, 2010; Wickramage et al., 2018), particularly in the case of HIV/AIDS (Lurie et al., 2003; Crush et al., 2005).

Migrants are at risk of poor health for several reasons, and the risk has become worse as host nations are unprepared to deal with the increased numbers. A migrant's health and well-being depend on the phase of migration. For example, migrants seldom make a plan before migrating for how they will manage their health in the host country (Gushulak et al., 2009), and this poor pre-migration planning creates health risks both during and after the migration (Martinez et al., 2015). The travel phase holds social and environmental risks, particularly if the migration is illegal (Gushulak et al., 2009). Migrants outside the legal system seldom access formal healthcare services, and the loss of social networks during migration creates health concerns (Bhugra, 2004). Travel increases the risks of physical and mental trauma, violence, exposure to bad weather and injury (Gushulak et al., 2009). Health threats after migration result from administrative, social and psychological factors. Poverty, legal restrictions and linguistic and cultural isolation can affect the physical and mental well-being of migrants in host countries (Gushulak et al., 2009). Migrant health policies in host countries are often anti-migrant (Veary et al., 2016) and involve complicated administrative processes (Fleischman et al., 2015). Migrants have a lower chance of receiving healthcare than local citizens (Martinez et al., 2015). Finally, on returning to their own country, migrants may also experience health problems because of their travels, and they can spread new diseases to their original locations and overburden the local health system (Davies et al., 2011).

8.2.2 Capabilities, Migration and Health

Sen (2005) developed the capabilities approach as a counter-argument to mainstream economics. Figure 8.1 provides a conceptual overview (Robeyns, 2003). For Sen (1993, p. 266), the capabilities approach entails "concentration on freedoms to achieve in general and the capabilities to function in particular". The emphasis is on the values, freedoms, opportunities and choices people have to ensure their well-being. The capabilities approach uses two main concepts: capabilities and functionings (Sen, 2005). Functionings are the "doings and beings". Sen (1987, p. 36) describes functioning as "an achievement" related to "different aspects of living conditions" and capabilities as "notions of freedom", "the ability to achieve" and "the real opportunities you have". Capabilities are the freedom and opportunities one has to realise functionings, as in the bicycle example below. For Sen (1992), a capability is a set of vectors of functionings that are involved in a person's freedom to make life decisions.

The capabilities approach says that commodities (income and goods and services) enable functioning. But not all functionings lead to capabilities. The focus is therefore on capabilities rather than just the functioning that is achieved. Robeyns (2003) identifies three types of conversion factors that enable a person to move from a functioning to a capability: personal, social and environmental. Personal factors include aspects such as intelligence, sex and physical ability. For example, possession of a bicycle will not lead to a capability for a disabled person: the disability will prevent the functioning of riding the bicycle. (In this chapter, we specifically did not include personal factors.) Examples of social factors are policies, social norms and power relations. Environmental factors include climate, infrastructure and social goods. The capabilities approach focuses on the freedoms that people can achieve (Sen, 2005; Robeyns, 2018). It also notes that people have choices because ideas of what constitutes a good life differ. Respect for a person's choices is central to the capabilities approach.

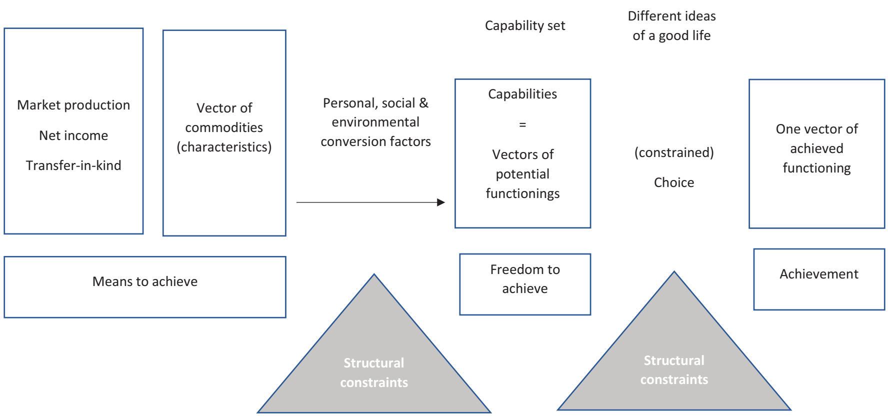

Fig. 8.1 Conceptualisation of main ideas in the capabilities approach (Source: Robeyns, 2003)

The capabilities approach notes that structures (laws, norms, rules and environmental conditions) can inhibit people from developing capabilities. People's interaction with structures determines the amount of freedom (achievement of capabilities) they have (Sen, 2005; De Haas, 2014). Agency is the ability to develop capabilities despite the restricting structures and even to change the structures.

Nussbaum (2002) identifies eight capabilities: bodily health; bodily integrity; senses, imagination and thought; emotions; practical reason; affiliation; and other species. The bodily health capability is the one most relevant to this chapter.

Research using the capabilities approach to investigate health issues focuses particularly on two capabilities: health agency and health as a meta-capability. Straehle (2015, p. 34) explains health agency as a person's ability "to make health-enabling decisions" and says that the "capability to do so should certainly not be hindered by public policy". Health agency research focuses mainly on conditions or factors that prevent people from realising their health capabilities. Health as a meta-capability means that health is an enabling condition for other decisions or choices. The meta-capability of health depends on four conditions: a person's biological endowments, the social context, the physical environment and the choices or decisions a person makes (Venkatapuram, 2013). Health as a meta-capability is assumed in this study as a necessary enabling condition for migrants. Our focus is on how migrants' agency to make health-enabling decisions is constrained.

The link between capabilities and migration remains underdeveloped in research. De Haas (2014) offers a capabilities framework within which to understand the capability to migrate. He links migration and capabilities: people's freedom to choose where to live is central to human mobility, and thus migration is a freedom per se (a capability). He says that human mobility largely depends on the capability to migrate and the factors enabling or preventing this capability. He uses the work of Berlin (1969) to distinguish between negative and positive liberties associated with migration. Negative liberty is the absence of obstacles to people's freedom caused by "states and politics (including war and violent oppression)"; positive liberty is "the ability to take control of one's life and to realise one's fundamental purposes" (De Haas, 2014, p.26), such as making migration decisions or being able to cope with migration processes.

In this chapter, we are concerned not with inability to migrate but with the factors that make it difficult for our sample of migrant workers to avoid being infected with HIV and in managing it if they are infected. These difficulties may be because of migration conditions – lack of privacy, for example. The social and environmental obstacles they encounter mean that they will have to exercise positive liberty, or agency, to stay healthy. We use the term "unfreedom", commonly used in the capabilities literature, to refer to the way structural constraints make the miners unable to manage the health problems caused by migration, in our case specifically the problem of avoiding HIV infection and getting treatment for it. Antiretrovirals are provided free by the mines in South Africa and the government in Lesotho. The means are there, but several structural constraints on the conversion factors prevent the miners from converting the means into capabilities. The shaded triangles in Fig. 8.1 show where these structural constraints play a role.

8.3 Methods

The study was conducted in July 2021. Our sample consisted of 50 interviewees recruited through purposive snowball sampling at the Maseru border post and popular street bars in Maseru, places where large numbers of migrant workers can be found. To participate, an interviewee had to be a Lesotho migrant miner working in the Free State, male, 18 years or older, and willing to participate. Disclosure of HIV status was not a prerequisite.

We used pamphlets in Sesotho (the local language) to recruit migrant miners. The pamphlets had information regarding the study and an invitation to contact the first author. Participants received 200 ZAR cash as compensation for their time (equivalent to about 13 USD at the time). Snowball sampling followed: at the end of a successful interview, the participant was asked if he knew anyone in a similar position who might participate and if so give the contact details of the first author to the potential participant. To avoid implied disclosure of their HIV status, the potential participants were given an information sheet (in Sesotho) and told that it was for them to keep or to give to other potential participants. The process of consent was fully explained in Sesotho. Ethical clearance was obtained from the General/Human Research Ethics Committee, University of the Free State.

The interviews were conducted in Sesotho, each taking approximately 90 minutes. The interview schedule did not explicitly require participants to describe their sexual behaviour. Our questions asked participants to reflect on "what migrant workers like them do". The responses were audio-taped and transcribed. The audio tapes were kept in a safe place, were not shared with unauthorised persons and will be destroyed upon completion of the research. The data was transcribed and then analysed using thematic analysis. This analytic method involves the transcripts being read, re-read and examined for recurring themes and how the participants portray the themes. The themes were then coded using Atlas ti 9 and categorised and compared to discover relationships between the themes.

For this chapter, we specifically focused on the constraints the respondents mentioned. A future study will look at positive aspects they mentioned, that is, the factors that enable conversion to capabilities. We also excluded personal conversion factors because we wanted to understand the structural constraints.

8.4 Migrant Workers' Constraints in Managing HIV

Constraining social and environmental factors prevents the migrant miners from having the conversion factors necessary to achieve the capabilities they need. (For this chapter we specifically did not look at personal factors.)

8.4.1 Constraining Social Factors

8.4.1.1 Acceptance of Commercial Sex

The culture of commercial sex at the mines in South Africa makes it difficult for the miners from Lesotho to prevent or manage HIV infection. Most respondents said commercial sex is commonly available or normal and acknowledged its health risks. They used expressions like "they are marketing themselves" and "they put our lives at risk" to describe commercial sex. Other commonly used expressions were "it's confusing" and "we don't understand it" and "we are overwhelmed". One respondent said:

> A lot of ladies arrive there intending to seduce men. They are marketing themselves when they go there. We don't finish because when you have met one and feel like you now trust them, another one comes. And that puts our lives at risk because you don't know the health condition of the next one. (Respondent 17)

This seems to imply that commercial sex at the mines is readily available, difficult to avoid and risky. It suggests that an unequal power relation between the sex workers and the miners makes the miners submissive to commercial sex. Several respondents said they were "losing control". Many reported a high prevalence of migrant workers engaging in unprotected sex with multiple and unknown partners.

Despite resentment and a perceived lack of control, many respondents willingly participated in the commercial sex culture. They wanted to "fit in" and they enjoyed the change of lifestyle. They commonly used expressions like "what happens at the mines stays at the mines", implying that they can do as they wish but can revert to their traditional values when going home. They see no need to tell their partners when they get home.

Our respondents' experiences support literature on South African mines and HIV that associates a high prevalence of HIV with migrant work (Maloka, 1997; Crush et al., 2005; Stuckler et al., 2013). Accepting commercial sex as normal is a social problem limiting the miners' capabilities to avoid risky behaviours. The respondents' view of themselves as helpless victims of commercial sex shows the social context hindering the conversion factors that would give them the capability to achieve bodily health. At the core of this unfreedom is not being able to bring their families from Lesotho to South Africa or not wanting to.

8.4.1.2 Social Isolation

Some respondents said they isolated themselves to avoid the risks of contracting HIV. Social isolation leads to a lack of meaningful social engagement between people (Parkhurst, 2012) and is not uncommon in migrant populations. The fear of "catching HIV" was the main reason for isolation. However, the respondents acknowledged that their isolation from their social networks hindered their access to HIV information. The response of one respondent summed up the overall feeling:

he said "we experience difficulties" in socialising with others. Self-isolation can limit access to informal HIV prevention and management resources such as HIV information. Also, self-isolation can create negative mental states like uneasiness and difficulty expressing oneself.

For the miners, self-isolation is both a functioning and a social constraint in managing HIV. But it is also an unfreedom. Social isolation limits their HIV knowledge and makes them unable to talk to others about HIV. Their social conversion factors are constrained by their inability to affiliate with others (affiliation is a capability in Nussbaum's list of capabilities) and a lack of HIV knowledge and advice from others.

8.4.1.3 Migration Policy

We make a distinction between historical and more recent processes of migration. Historically, and until the mid-1990s, migrants lacked choice in making migration decisions. Many respondents said that their work contracts and schedules determined their migration patterns. Often, they did not have the choice to go home even if they were off duty. Three respondents elaborated on their initial lack of control over their migration decisions in the 1990s:

> You spend the first four months working before signing the contract. After signing the contract, you can take a leave of the length you desire. (Respondent 9)
>
> I didn't come home for a long time because I was still new to the job… I came when I got my first leave. (Respondent 9)
>
> I did not come home often. I came home maybe after four months or five months. It is impossible to come home every month, for different reasons. (Respondent 13)

The quotations reflect a lack of migration decision-making and a lack of options. Migrants in those days had constraints imposed by the state and the mining companies. The inability to return home when they wished or as often as they wished and the resulting interrupted contact with family and partners led to an increase in HIV infection in the 1990s and early 2000s (Crush et al., 2005). Our interview data suggests that being away from home and commercial sex was a prominent cause. Many respondents felt that living away from their wives obliged them to engage in risky sexual behaviour. Their statements illustrate the effect of South Africa's historical migrant labour system on the miners' choices and decision-making. Effectively, South African legislation limited migrants' freedom to determine their own migration patterns and behaviour.

However, these historical restrictions have largely disappeared. A decrease in the migration restrictions (scrapping of influx control, border control and employment restrictions) has contributed to more regular migration. Many respondents said they migrate regularly between South Africa and Lesotho (circular migration). The proximity of the Free State mines to Lesotho (e.g. the distance from Maputsoe to Welkom is 200 km) drives their migrations, and migrant labour has contributed to Lesotho households moving closer to Lesotho's border with South Africa. However, their repetitive travel is risky as travel on the roads between the two countries is considered at high risk for sexual HIV transmission. The town of Maseru, the port of entry with South Africa, is a popular location for sexual intercourse. Respondents said, for example, "These prostitutes are everywhere" and "Many things happen during travel, including sex workers".

The responses resonate with the wider literature that notes that the high burden of HIV at South Africa's mines is a consequence of the miners' prolonged absence from their families (Crush et al., 2005; Rajak, 2010; Steele, 2013). Public transport fosters sexual HIV transmission through encounters with sex workers. While public transport (mostly minibus taxis) broadens the miners' choices (historically, they commuted by company buses or trains), it also increases their chances of HIV infection. These findings are supported by earlier research (Palk & Blower, 2015) which also reported that the chances of Lesotho male migrants having multiple sexual partners while travelling are high.

8.4.2 Constraining Environmental Factors

8.4.2.1 HIV Programmes

Our interview data also suggested that the implementation of HIV programmes in Lesotho and South Africa constrained migrants' capabilities. We highlight five constraining factors apparent from our interviews.

Firstly, historical disease control programmes at the mines were harsh, restricting the miners' opportunities to develop agency. A disease-centred approach does not consider the social context. Mining companies initially ignored the reality of HIV/AIDS (Rajak, 2010). Older respondents had experienced the mines' harsh and coercive systems between 1990 and 2010. One said the miners would get a "red tab" on their medical booklets if diagnosed with an STI (sexually transmitted infection). The respondent said:

> If one were to catch one with gonorrhoea or syphilis, one would have to go through rigorous inquiry by the health authorities to establish where one got infected. One got a red tab in one's medical book to inform the authorities that one had a record of such infection. The label in one's medical booklet would then read 'Accident without company' [sic]. (Respondent 4)

The quotation shows how, in the early years of the pandemic and even as late as 2010, mining companies did not take responsibility for helping employees to get treatment (presumably because the "accident" had occurred outside the company's premises and was thus not legally their responsibility). This disease-centred approach runs counter to the people-centred approach to healthcare recommended by the WHO and ignores the role of health as a meta-capability. For example, good health will enable higher levels of productivity. The WHO emphasises people's needs, preferences and expectations and principles like dignity and respect (WHO, 2021). The management of the disease in the way described in the quotation does not comply with these principles.

Secondly, administrative bottlenecks prevent access to treatment. The historical approach outlined above began to change in 2010. Many mining companies have progressive policies for antiretroviral treatment. The WHO “treat-all” recommendation emphasises the importance of rapid initiation of antiretroviral treatment. This includes same-day antiretroviral treatment following diagnosis (if there are no clinical contraindications). Despite the policy changes, however, many respondents said that access to initial antiretroviral treatment at the mines is difficult and restrictive for foreign migrants. They used expressions like “not easy”, “not being able to collect antiretrovirals” and “being asked for a referral letter”. One respondent elaborated on the difficulty migrants could encounter in accessing antiretroviral treatment at the South African mines:

> My colleague had to spend some days without his medication. They got them here in Lesotho and then sent them to him by courier. (Respondent 12)

The South African mines have made antiretroviral treatment available, but most respondents said that without a referral letter, access to initial antiretroviral treatment was difficult for migrants.

Thirdly, the attitude of healthcare workers at the mines can be a constraining factor. Some respondents thought that it was these attitudes that denied migrants basic healthcare entitlements. They blamed this on the culture environment. Most respondents believed that the healthcare workers have negative attitudes towards foreign migrants. The following remarks are illustrative:

> There are still problems on the South African side due to attitudes. Foreigners are still viewed condescendingly, perhaps due to the previous regimes or just that people are tribal in their minds. (Respondent 4)
>
> When we first arrived, the health workers were elderly people who understood approaching people, especially males. Right now, you find that you’re served by younger people who are always on their phones. Sometimes you find that they make fun of people. There’s an older man they laugh at, wondering why he is using ARVs at this age. It makes people scared of going to a hospital when sick. (Respondent 12)

The quotations highlight how negative attitudes could affect migrants’ access to health facilities. The respondents perceived a lack of fair opportunity between local and migrant miners. Sen (2005) defines fair opportunity as non-discrimination and equality between groups. Our interview data supports a study that found that health providers bar healthcare access for migrants even when clear guidelines are available (Veary et al., 2016). The second quotation illustrates health workers’ negative attitudes, consisting of ridicule, humiliation and ageism, that evoke fear. Respondents mentioned unethical behaviour, lack of motivation and a disregard for providing a good service.

The negative attitudes can constrain the migrants’ capability to access healthcare. Some respondents said they were ridiculed when seeking HIV services. Describing the health workers’ attitudes, they said “they make fun of people”, “they laugh” and “they are always on their phones”. Healthcare workers’ abuse of migrants seeking healthcare was noted in a study by Wickramage et al. (2018). Some respondents said the mines’ health services were deteriorating.

Fourthly, workplace policies and programmes can also be a constraining factor. Sometimes work commitments at the mines are prioritised over the miner's healthcare needs. Some respondents prefer to access antiretroviral treatment in Lesotho, but others said it is not always possible to go to Lesotho because of work commitments. Some felt that their health needs generally, such as going to see a doctor or going for medical check-ups, are often not considered by the mining companies.

Finally, healthcare policies and programmes in the country of origin can also be a restricting factor. The respondents perceived healthcare services in Lesotho as poorly organised, low efficiency and low quality. They mentioned recurring incidences of lost files, overcrowding and constant staff changes. They used expressions like "I lost faith in their services". One respondent described his experience of lack of organisation at a Lesotho clinic thus:

> I encountered a challenge because my file was missing. Therefore, they concluded that I was not on antiretrovirals. But then they believed me because I had that day's bottle of antiretrovirals containing the last pill. It was that incident that helped me. (Respondent 42)

The quotation suggests that some clinics in Lesotho may be disorganised and inefficient. It suggests power relations between patients and healthcare workers in Lesotho that work against patients and threaten their healthcare entitlements. This contradicts other impressions mentioned above. Respondents were split 50/50 on whether HIV services in Lesotho were good or bad. Some respondents also mentioned alienation of the Lesotho HIV clinics' users that fostered negative health outcomes such as interruption or abandonment of antiretroviral treatment.

The lack of organisation and efficiency, the slow service and the healthcare workers' negative attitudes are capability constrainers that diminish the migrants' agency and their freedom to be healthy. Their capability to access HIV services and adhere to antiretroviral treatment is constrained. The respondents' perceptions suggest that it is institutional incapacity that obstructs access to HIV resources.

8.4.2.2 Housing

As South Africa's mine housing policies do not provide adequately for miners' accommodation, they find themselves in living spaces that reduce their capability to prevent and manage HIV infection. Most respondents felt their living conditions at the mines were inadequate and contributed to risky sexual behaviours. The respondents spoke about sharing accommodation and being unable to bring their wives or girlfriends to live with them because of a lack of privacy (a condition that causes unfreedom). Inadequate family living space and lack of privacy drive the miners to communal spaces such as brothels and bars, where risky sex behaviours are rife.

One respondent said he and seven other miners were living in one large room divided into sections by wardrobes. This is a clear example of the inadequate, overcrowded living spaces that lack privacy and are unsuitable for family living. Inadequate access to decent housing for migrants is widespread. Mine policies do not provide adequately for the miners' accommodation needs, resulting in substandard living spaces that incite risky behaviours. Our interview data supports research findings about living conditions at the mines in South Africa (e.g. Marais and Venter (2006), Pelders and Nelson (2019)).

8.4.3 A Combination of Social and Environmental Constraints

The overarching capabilities that would be fostered by good quality healthcare are the capability to access HIV services, adhere to antiretroviral treatment, be healthy and have choices from various available opportunities and options. Low-quality healthcare, on the other hand, restricts these capabilities. Linking this to the capability literature, we can say that our respondents' perceptions suggest that the mine policies and laws restrict the miners' freedoms, agency and choice. The mine policies create unfreedom (and have particularly done so historically), constraining the miners' capabilities to access antiretroviral treatment in Lesotho (despite some making arrangements to access it there). Restricting freedoms can substantially constrain agency and choice. Unfreedom pertaining to migration is caused by a combination of social and environmental factors that separate families, lead to risky sexual behaviours and discourage sensible healthcare practices, disabling the miners' capabilities to protect themselves from HIV.

8.5 Conclusion

The capabilities approach to health often focuses on health agency or people's ability to make decisions leading to good health. Migrant miners have access to free antiretroviral treatment, but many migratory, social and health programme factors prevent them from achieving a healthy life. Some of these factors are by choice, but others are structural constraints hindering the freedom to achieve good health or prevent and manage HIV. The migrant status and migration processes often make it difficult to manage or prevent HIV. Institutionalised migrant labour has been core to the high incidence of HIV among migrants. Initially, mining companies distanced themselves from the problem and saw contracting gonorrhoea as an "accident without company". This has changed and so has institutionalised migrant labour. But access to HIV information and treatment is no guarantee that migrants will take up the treatment or practise safe sex. The absence of family, the widespread availability of commercial sex and the complications of the migration processes remain factors that inhibit agency and prevent the achievement of positive liberty through realising their capabilities.

To prevent HIV infection, migrants either need to have safe sex or not engage in commercial sex. The nature and scale of commercial sex associated with the masculinity of the mining industry are overwhelming for some. Housing conditions are poor and often do not guarantee privacy. Some respondents used self-isolation to avoid commercial sex. Yet, isolation also minimises their social functioning and prevents access to HIV information.

Although antiretrovirals are available for miners, numerous factors prevent them from converting these means into functionings and capabilities. Historically, the mines did not see this as their responsibility, so migrant workers had to find ways to manage or prevent HIV on their own. Today mining companies are directly involved in these processes. Yet, as many of our respondents said, migrants are often confronted by direct and tacit discriminatory practices. Some constraints are related to administrative processes, but others are embedded in health workers' attitudes towards migrants. Policymakers and mines must take note of these constraints to finding equitable health responses for migrant workers in South Africa. The mining industry needs to provide miners with the agency to manage and prevent HIV infection.

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Chapter 9
Geographical Analysis of Malaria in Nigeria – Spatiotemporal Patterns of National and Subnational Incidence

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9.1 Introduction

Malaria is a vector-borne infectious disease, causing illness, and deaths, and therefore remains one of the biggest public health concerns in tropical and subtropical regions of the world, especially in South and Latin America, Sub-Saharan Africa, and Southeast and Central Asia (Prothero, 1995; WHO, 2008). Malaria is caused by the protozoan parasites of the genus plasmodium. Human malaria is normally caused by different species of *plasmodium;* they are *P. falciparum, P. malariae, P. ovale,* and *P. vivax.* Among these species, *P. falciparum* is the most significant and deadly form of malaria, presenting severe health risks, especially in Sub-Saharan Africa where it is endemic (WHO, 2011). Humans occasionally get infected with plasmodium species that commonly infect animals, such as *P. knomlesi*.

In parts of the world where malaria is prevalent, human malaria species are not equally distributed, and their relative importance varies between and within different regions. As a result, the risk of acquiring malaria varies greatly from country to country and even between regions within a single country (WHO, 2013). According to the National Malaria Elimination Programme (NMEP), National Population

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Commission (NPC), National Bureau of Statistics (NBS), and ICF International, *P. falciparum*, the most dangerous species of malaria parasite, is the most prevalent species in Nigeria and accounts for more than 95% of all malaria (2016). *Plasmodium ovale* and *P. malariae* are two local species that have a small impact.

The female anopheles mosquito, which bites predominantly between dusk and dawn, is the principal vector for the transmission of the plasmodium parasite from one person to another (WHO, 2013). There are more than 400 different species of Anopheles mosquito, but only around 40 of them have been recognised as significant human malaria vectors (Hill & Meek, 2007). The majority of malaria transmissions in Nigeria are caused by the *Anopheles gambiae* complex and the *Anopheles funestus* group, which are the primary vector species in the country (NMEP, NPC, NBS, and ICF International, 2016).

Environmental features have a significant impact on the abundance and growth of malaria vectors since they are quite sensitive to them (Abiodun et al., 2016; Akinbobola & Ikiroma, 2018; Roll Back Malaria, 2015). The spatial distribution of vectors and the illnesses they transmit are greatly influenced by a variety of factors, including climate, terrain, population density, land use and land cover, proximity-related factors, and other anthropogenic factors (Afrane et al., 2007; Bhattacharya et al., 2006; Kalluri et al., 2007).

9.1.1 The Geographical Context of the Country

Geographically, Nigeria is located in the West African sub-region between latitudes 4°16′ and 13°53′ north and longitudes 2°40′ and 14°41′ east. Its northern, north-eastern, eastern, and western borders are shared with the Niger Republic, the Republic of Chad, and the Republics of Cameroon and Benin. Nigeria's southern boundary is formed by the Atlantic Ocean. The total land area of Nigeria is 923,768 km^2 (Fig. 9.1).

Nigeria has a tropical climate with wet and dry seasons that are influenced by the movement of the two main air masses: the tropical maritime air mass (originating from the Atlantic Ocean) and the tropical continental air mass (originating from the Sahara Desert). The dry season, which lasts from October to March, is characterised by a period of cooling accompanied by the dry, dusty Harmattan wind, which is particularly noticeable in the north in December and January. Between April and September is the wet season. Nigeria's annual temperature ranges from 25 to 40 degrees Celsius, and its annual rainfall varies from 2650 mm in the southeast to less than 600 mm in some areas of the north, mostly near the Sahara Desert. The vegetation of the nation follows the same pattern as the rainfall, becoming denser in the south and sparse in the north. Topographically, the nation is made up of numerous sizable highlands and lowlands. Among the highlands, the Jos plateau, Udi plateau, Adamawa highlands, Obudu plateau, and Oban hills stand out. The Niger Delta, Niger-Benue trough, Chad Basin, Sokoto plains, and Borno plains formed the topographical features.

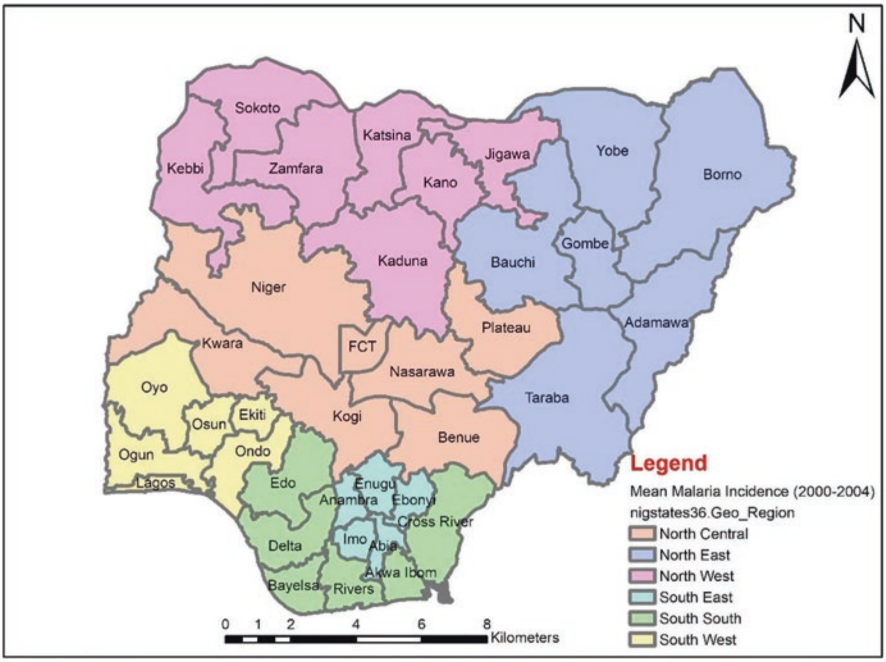

Fig. 9.1 Map of Nigeria

There are 36 states plus the Federal Capital Territory (FCT) and six geopolitical regions in the country. The political regions are: the North East (NE), North West (NW), North Central (NC), South West (SW), South East (SE), and South-South (SS). The states are further divided into 774 Local Government Areas (LGAs). Nigeria is the most populous country in Africa and the seventh largest in the world (NMEP, NPC, NBS, and ICF International, 2016). The 2006 Population and Housing Census indicates that there are 140,431,790 people living in Nigeria. According to the NPC projection, the number will reach 216,783,381 in 2022 (NPC, 2009).

Malaria still has a terrible impact on people's health and way of life all over the world, despite the fact that it can be prevented and treated. Nigeria is one of the countries in the world with one of the highest rates of malaria prevalence. In 2020, there were 241 million cases of malaria reported worldwide, with 95% of those cases coming from the WHO African region. The number of malaria deaths worldwide in 2020 was estimated to be 627,000, with 29 of the 85 malaria-endemic countries (including French Guiana) accounting for approximately 96% of the total (WHO, 2021). Countries in Sub-Saharan Africa, where malaria transmission is moderate to high and surveillance is frequently ineffective, bear the majority of the burden of the disease globally. In 2020, Nigeria was responsible for 26.8% and 31.9% of the world's malaria cases and deaths, respectively (WHO, 2021). According to these figures, Nigeria is the most endemic malaria country in the world.

There is widespread malaria transmission in Nigeria, with 76% of the population residing in high- and 24% in low-transmission areas (WHO, 2017). It is estimated that 30% of hospital admissions and 60 percentage of outpatient visits in Nigeria can be attributed to malaria. Additionally, it accounts for up to 11% of maternal deaths, 25% of infant deaths, and 30% of deaths among children under the age of five. Nearly 300,000 children die each year from malaria-related causes, with an estimated 110 million clinically recognised cases of the disease (NMEP, NPC, NBS, and ICF International, 2016). In addition to morbidity and mortality, malaria has a significant negative social and economic impact on the nation. According to the Federal Ministry of Health (FMoH) and NMEP (2014), it reduces the nation's gross domestic product (GDP) by 40% each year and costs roughly 480 billion naira (more than $1 billion USD) in treatment and prevention expenses as well as lost wages from workers who are unable to work while ill.

Since the early and mid-twentieth century, non-geographers have dominated earlier efforts on malaria in Nigeria. Here, three significant studies stand out: Barber, Olinger, and Puman (1931), Darker (1903), and Archibald (1956). The article Darker wrote for the editor of the Journal of the African Society demonstrated how Europeans' activities – such as opening up new areas for development – had exposed the Sapele mosquito population as a significant barrier to the fight against malaria. With a focus on Lagos and Ebutte Metta, Barber, Olinger, and Puman studied the malaria parasite index in specific age groups. By examining malaria in the south- and north-western communities of Ilaro and Birnin Kebbi in the provinces of Abeokuta and Sokoto, respectively, Archibald broadened the area of his own investigation. His study, like others, examined the epidemiology of malaria in these regions using geographic characteristics including climate. The work of Prothero (1961a, b, 66) examined malaria in Nigeria, focusing on how it influences the eradication of malaria among migratory populations. Since then, geographers have conducted more research on malaria using a variety of techniques, primarily at the community, local, state, and regional levels (Abdulkareem et al., 2017; Gambo et al., 2020; Ndace, 2020; Simon-Oke et al., 2016; Abdulkadir et al., 2015; Akinbobola & Ikiroma, 2018; Ogoro et al., 2022), except for a few studies: Oluyemi and Oyeyemi's (2019) analysis of the spatiotemporal relationship between malaria incidence and environmental predictors where they only used data from the Demographic Health Survey and the National Malaria Index Survey from the years 2000 to 2015 in their analysis; the work of Ugwu and Zewotir (2020) that examined the spatial distribution and sociodemographic risk factors of malaria in Nigerian children less than 5 years old; the study of Tolulope (2014) on Spatio–Temporal Clustering of Malaria Morbidity in Nigeria (2004–2008) and that of Oyibo et al. (2021). The analysis of malaria in this study focused on the spatial, temporal, demographic (including malaria in pregnancy) and environmental factors influencing its prevalence. Data from 2000 to 2021 were used.

9.2 Spatial Distribution of Incidence

9.2.1 Distribution by Geo-political Region

The overall (2000–2020) mean incidence rate of malaria across the six geopolitical regions ranged from 312.2/1000 to 436.8/1000 population showing a fairly wide variation. Political regions were grouped into five classes based on the intensity of the mean incidence rate as very high, high, moderate, low, and very low. Figure 9.2a shows that very high and high incidence rate of malaria concentrates in the Northern Nigeria, while low and very low incidence were found in southern part of the country. The north west geopolitical region that is categorised as very high had 436.8/1000 individuals as mean incidence rate. North central and north east that fall under high incidence category had 3.88.6/1000 and 358.5/1000 individuals, respectively. South west geopolitical region that reported the lowest mean incidence of 321.2/1000 people formed the very low incidence class. Based on our analysis, all the three regions from the southern part of the country had an incidence rate that was lower than the national incidence rate of 357.7/1000 persons. In contrast, all the three geopolitical regions from the north had their incidence rates higher than the national figure. This shows that northern part of Nigeria is more endemic in terms of malaria transmission compared to the southern part.

The spatial distribution of malaria incidence in the 2000–2004 periods shows that north central and north west regions were classified as very high and high incidence regions. They recorded mean malaria incidence rates of 468.3/1000 and 426.6/1000 population, respectively. North east and South west were categorised as low and very low incidence region with 386.1/1000 and 3854.3/1000 people as incidence rates (Fig. 9.2b). From our analysis, the two regions with highest incidence are all from the northern part of the country. However, from the southern part, south-south recorded 420.4/1000 population, which is slightly lower than that was obtained in North West region. The national mean incidence for this period was calculated as 402.3/1000 persons. The analysis further shows that two regions one from the north and one from the south had their incidence rates below the national average (402.3/1000). This indicates that malaria incidence during this period is not concentrated to any part of the country.

The picture of malaria mean incidence in 2005–2009 is somewhat similar from that of 2000–2004 as shown in Fig. 9.2b, c, once again, north central, north west and south west regions maintained their status as very high, high, and very low incidence regions, respectively. During this period, they had an incidence rate of 484.0/1000, 437.7/1000 and 348.5/1000 population, respectively. South-south on the other hand emerges as low incidence regions with 376.7/1000 people as incidence rate. Mean malaria incidence in geopolitical regions experienced an increased in 2005–2009 period compared to 2000–2004 period. The only exception is in south-south and south west where a drop is observed. The four regions that registered an increased in the mean incidence had their rate high than the national fig.

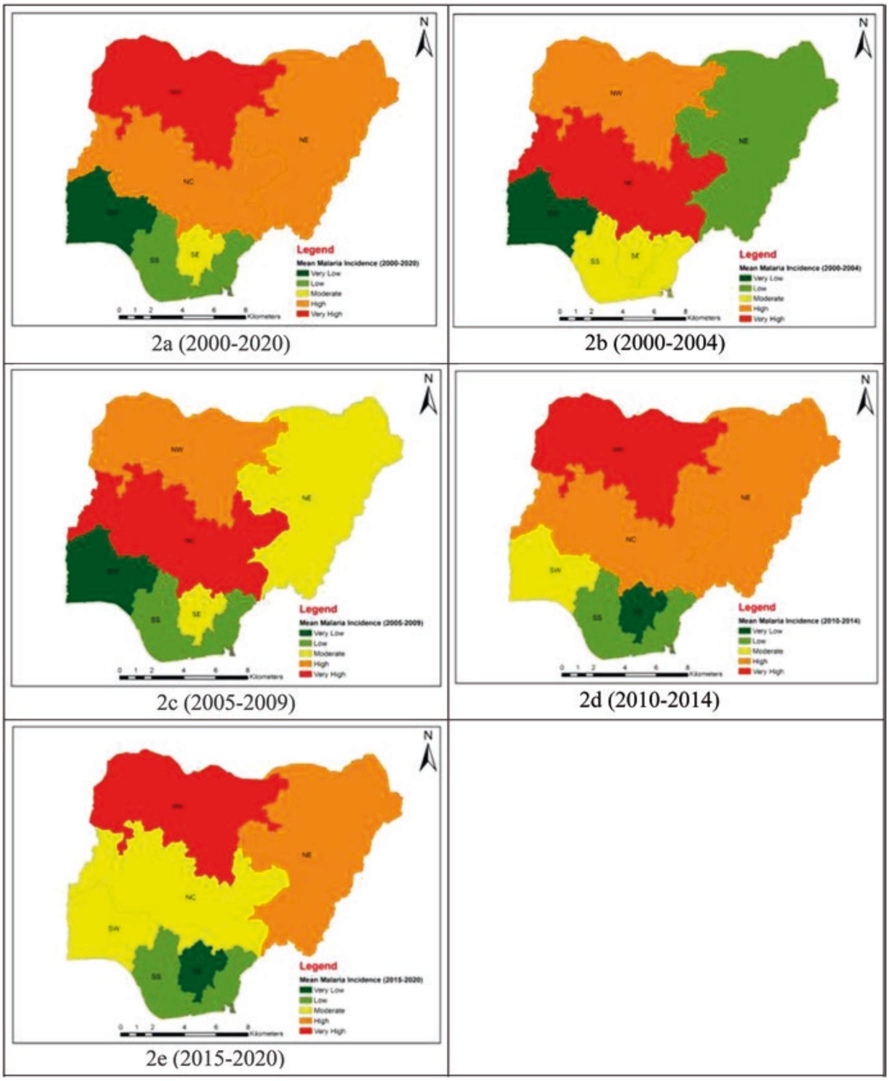

Fig. 9.2 Mean malaria incidence by geopolitical regions

408.9/1000. However, south-south and south west had their rates less than that of the national.

As regard to 2010–2014 period, different pattern emerged as shown in Fig. 9.2d. North west recorded the highest incidence rate (480.0/1000); thus, it belongs to very high category. North central region and north east during this period fall under the high incidence regions. They recorded mean incidence of 336.7/1000 and 327.1/1000 population. South east that registered 252.7/1000 as mean incidence formed the very low incidence class. Between 2005–2009 and 2010–2014 periods, north west experienced an increased in the mean incidence from 437.7/1000 to 480/1000 individuals. All the remaining five geopolitical regions had a drop in their mean incidence between the two periods. The data further revealed north west and north central as the only regions with mean incidence that exceed the 331.5/1000 recorded for the national.

For the 2015–2020 period, north west, north east, and south east maintained their position in the very high, high, and very low mean incidence classes, respectively. They were associated with 386.8/1000, 305.3/1000, and 231.3/1000 people mean incidence. During this period, all the regions witnessed reduction in their mean incidence compared to the previous period. At this period, as like the previous, north west and north central had their mean incidence higher than 299.6/1000 obtained for the national, while all others had below the national average. The mean incidence of malaria was consistently from 2000–2004 to 2015–2020 period in all the six regions except north west that experiences an increase from 2000–2004 to 22,010–2014 periods and north central that witnessed increase from 2000–2004 to 2005–2009 periods.

9.2.2 Distribution of Malaria Mean Incidence by States

The cumulative (2000–2020) distribution of the mean incidence of malaria is depicted in Fig. 9.3a. The figure shows that two states (Zamfara and Kebbi) reported the highest mean incidence rates of 494.8/1000 and 484.3/1000, respectively, falling into the very high mean incidence class. Similarly, 12 states (Sokoto, Kaduna, Kano, Katsina, Bauchi, Gombe, Plateau, Nasarawa, Benue, Ebonyi, Kwara and Niger) were identified as having a high mean incidence. Four states, Lagos, Ogun, Delta, and Enugu, recorded 110.6/1000, 254.8/1000, 256.9/1000, and 254.7/1000 individuals, respectively. These four states, therefore, constituted a very low mean incidence class. The overall national mean incidence was computed at 357.7/1000 population. Based on this figure, 23 out of the 36 states had their mean incidence rate higher than the national figure.

The spatial distribution of malaria mean incidence in the 2000–2004 period indicates that the very high incidences were recorded in Kwara, Niger, Kaduna, Nassrawa, Imo, Abia, and Akwa Ibom. They had a mean incidence of between 435.5/1000 and 570.6/1000 population, with Kaduna registering the highest mean. The high incidence class had 14 states, including Zamfara, Katsina, Kano, Kano, Bauchi, Gombe, Plateau, Benue, Ebonyi, Cross River, Rivers, Kogi, Ekiti, Osun, and Oyo. The mean incidence in this category ranged from 426.7/1000 people in Osun to 461.2/1000 in Cross Rivers. The lowest incidence of 108.2/1000 was recorded in Lagos, and it therefore formed the very low incidence class. During this period, 24 out of the 36 plus Abuja (Federal Capital Territory, FCT) had their mean exceed the national average of 402.3/1000.

For the 2005–2009 period, the very high mean incidence class had nine states, showing an increase of two states from that of the 2000–2004 period (see Fig. 9.3b, c). The states are Kwara, Kogi, Ebonyi, Benue, Nasarawa, Niger, Kaduna, Bauchi,

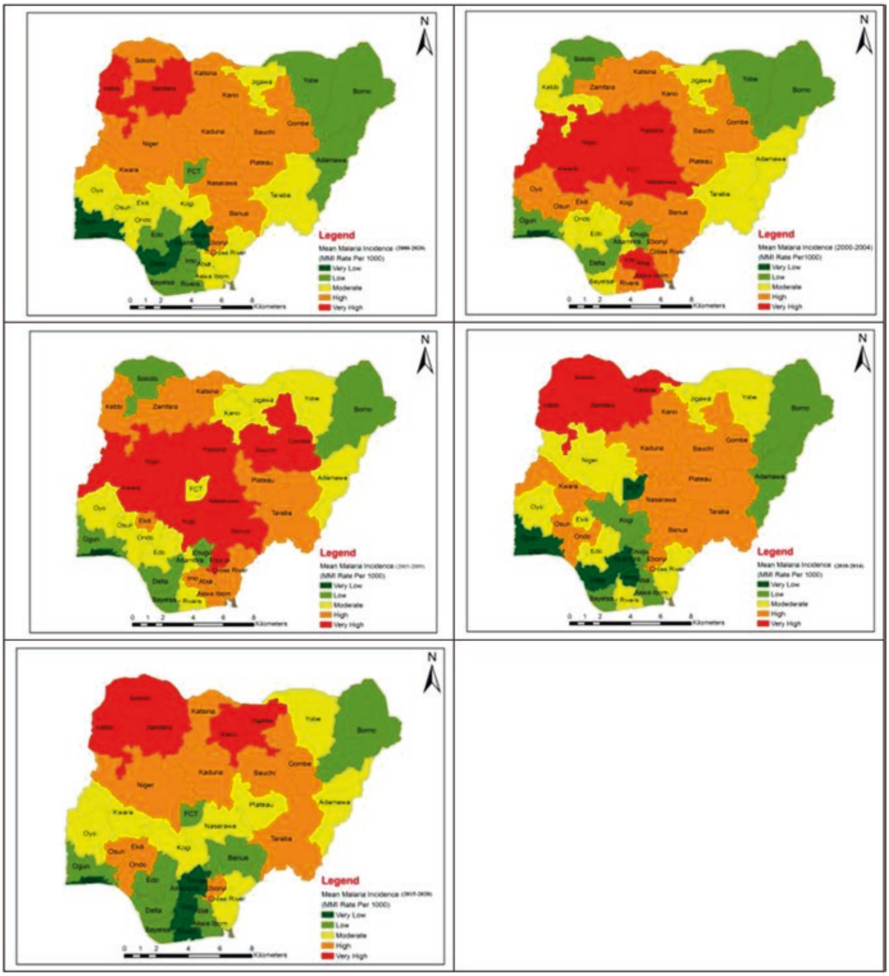

Fig. 9.3 Distribution of malaria mean incidence by states

and Gombe, with Benue having the highest incidence (518.2/1000) in the class. The high incidence class, on the other hand, saw a decrease of four states compared to the 2000–2004 period. The class now has ten states, which are Kebbi, Zamfara, Katsina, Plateau, Taraba, Cross River, Imo, Abia, Akwa Ibom, and Ekiti. Of these ten states, Zamfara recorded the highest mean incidence of 476.8/1000, followed by Kebbi with 475.3/1000 population. Figure 9.3c also shows Lagos as the only state in the very low incidence class. It has an incidence rate of 119.2/1000 people. For this period, 11 states recorded mean incidence lower than the national average.

Although the 2010–2014 period witnessed a reduction in the number of states that formed the very high incidence group from the 2005–2009 period, there was also an increase in the high and very low incidence classes. The 2010–2014 map indicates that Kebbi, Zamfara, Sokoto, and Katsina belong to the very high incidence group, while Lagos, Ogun, Delta, Imo, and Anambra fall under the very low incidence group. In the 2010–2014 period, Zamfara and Lagos states recorded the highest and lowest incidences of 619.1/1000 and 76.9/1000 population, respectively.

The 2015–2020 incidence map (Fig. 9.3e) shows Kebbi, Sokoto, Zamfara, Kano, and Jigawa as very high malaria incidence states. Sokoto state reported the highest mean incidence of 429.2/1000 individuals, followed by Zamfara with 423.5/1000 individuals. Furthermore, the figure identified Lagos, Rivers, Imo, Anambra, and Enugu states as having very low malaria incidence areas. During this period, 21 states and Abuja (FCT) reported mean incidences lower than the national figure. Generally, the majority of the states experienced an increase in the incidence from 2000–2004 to the 2005–2009 period and thereafter showed a continuous decline.

The pattern of malaria incidence cannot be fully understood by focusing on the mapping of incidence rates alone. In order to determine the incidence pattern, a geospatial data analysis approach must be used. This method improves our knowledge of the spatial distribution of malaria cases. Geospatial analysis highlights areas with clusters, whereas incidence rate mapping provides a generalised view of the distribution of cases. To determine the pattern of malaria incidence distribution, spatial autocorrelation analysis using Global Moran's *I* was conducted.

The result of the analysis is presented in Tables 9.1 and 9.2. The result of Moran's I given in Table 9.1 for the geopolitical regions revealed a random pattern in the distribution of malaria incidence for the entire period of the study.

Table 9.2, on the other hand, shows result of clustering for the 36 states and Abuja FCT. The table indicates evidence of insignificant clustering in 2010–2014, 2015–2021, and 2000–2020 periods, while 2000–2004 and 2005–2009 showed random pattern.

It is evident that malaria mean incidence has significantly decreased in all six of Nigeria's geopolitical regions and in most of states, even though the country still has the world's highest malaria burden (WHO, 2021). Massive efforts made by numerous parties may be responsible for the decline in malaria incidence in Nigeria. The national malaria control programme, for instance, received major financial support, supplies, and technical assistance from the Roll Back Malaria Partnership (RBM). The RBM Partners have additionally assisted the nation in creating proposals that may be funded and in securing sizeable funds from numerous international sources. Along with increased funding from the federal and state governments for the fight

Table 9.1 Pattern of malaria incidence for geopolitical regions

Malaria pattern in Nigeria (geo-regions)				
Year	Observed general G	*z*-score	*P*-value	Pattern
2000–2004	0.214352	0.86287	0.388209	Random
2005–2009	0.206437	−0.07882	0.937177	Random
2010–2014	0.183177	−1.133283	0.257096	Random
2015–2020	0.182279	−1.40507	0.16	Random
2000–2020	0.197242	−0.87958	0.379089	Random

Table 9.2 Pattern of malaria incidence for states

Malaria pattern in Nigeria (36 states and FCT)				
Year	Observed general G	z-score	P-value	Pattern
2000–2004	0.103032	0.3768	0.706322	Random
2005–2009	0.099663	−0.358	0.720342	Random
2010–2014	0.085217	−2.07965	0.037557	Low cluster
2015–2020	0.087608	−2.6593	0.00783	Low cluster
2000–2020	0.093065	−1.81426	0.069638	Low cluster

against malaria, participation from the private sector – including drug producers, importers, and distributors – has contributed to a reduction in the disease's prevalence in the nation.

This finding agrees with the result of a study conducted by Okunlola and Oyeyemi (2019), who also discovered in their study that malaria incidence in Nigeria's geopolitical regions decreased between 2000 and 2015. However, our result contradicts that of Adepojo and Akpan (2017), who found that confirmed malaria cases in Nigeria from 200 to 2015 have increased. The variation among the studies could be linked to the type and source of data used for the studies. Although southern part of Nigeria has environmental conditions such as high rainfall, dense vegetation, numerous surface water bodies that could help in the transmission of malaria, our study found that northern Nigeria have higher malaria incidence than southern part. According to Okunlola and Oyeyemi (2019), the changing pattern of high malaria incidence from the southern to northern part of the country may be attributed to poor access to healthcare and public health services in remote areas of the North as well as the effects of the rivers Niger and Benue. Microclimate, local ecology, vector adaptation to a particular niche, and increased irrigation projects are other plausible explanation for the observed pattern of the malaria incidence. Further, our study identified north west geopolitical region as the most endemic in terms of malaria. This result is not in agreement with the finding of Okunlola and Oyeyemi (2019) who found that north central is the region that carries the greatest burden of malaria in Nigeria. The discrepancy may be attributed to differences in data sources and investigation periods.

Focusing on the cumulative result, five states had the highest incidence of malaria in Nigeria. They are Kebbi, Zamfara, Katsina, Kaduna, and Niger. Among these states, Kebbi and Zamfara were the states with high burden. This finding was supported by the work of Oyibo et al. (2021) who studied a geographical and temporal variation of malaria infection among children under five years. Their results also showed Kebbi and Zamfara state as the most endemic states in terms of malaria infection. Regarding the low incidence areas, four states were identified to have low incidence of malaria. Largos state, for example, consistently appears as very low incidence state for the entire period of analysis. Other areas with low mean incidence are Ogun, Delta and Enugu, which are all from the south. This finding is very surprising due to the fact that household ownership of Insecticide Treated Nets (ITNs) is the highest in the north west (87%) and almost all the states in the region have achieved the national target of 80%, while it is lowest in the south west (44%) (NPC and ICF International, 2019). In addition, Kebbi state that had the highest mean incidence in the country had the highest percentage of household ownership of ITNs, while Lagos state that recorded the least mean incidence also had the least proportion of household who owned ITNs. Understanding the reasons for the observed result is of utmost importance, as is determining whether or not new interventions are needed or whether targeted expansions of current ones would be successful. Results of cluster analyses revealed absence of significant cluster of malaria in the country both for geopolitical regions and states. This result shows that malaria in the country is so endemic and spreads all over, indicating similar transmission pattern.

9.3 Temporal Distribution of Malaria in Nigeria

The occurrences of Malaria from 2000 to 2020 show a general decline in the number of mean incidences from 418 to 313 per 1000 persons, respectively. Figure 9.4 shows a gradual decline from 2000 to 2003 with mean incidence of 418 dropping to 391 per 1000 persons. There was a gradual rise again from 2004 to 2008, which was followed with a drastic drop 2009 to 2017 with 400 and 292 mean cases per 1000

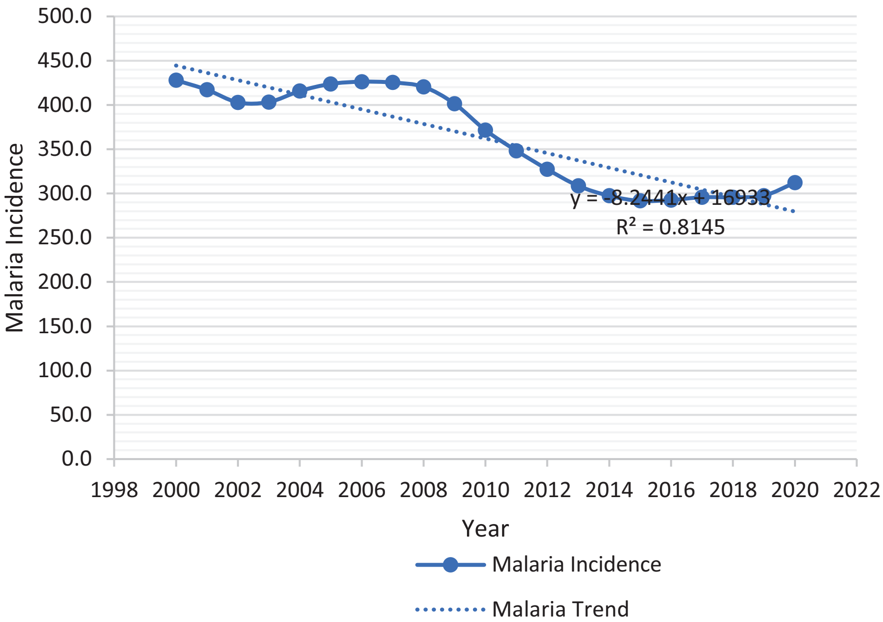

Fig. 9.4 Mean annual trend of malaria in Nigeria (2000–2020)

persons, respectively. However, the cases started rising again in 2018 to 2020 recording mean annual cases of 299 to 313 per 1000 persons, respectively.

This implies that the disease is endemic throughout the period of study despite the fact that it is declining. The decline is as a result of intervention from the Global Fund, USAID's President's Malaria Initiative, and other organisations that provide funding to the Nigerian government for the fight against malaria. The World Bank, the African Development Bank, and the Islamic Development Bank have all granted loans to the country. Similar funding has been provided to the nation by DFID (now known as the Foreign, Commonwealth & Development Office (FCDO)) and a variety of nongovernmental organisations. The used of insecticide treated nets (ITN) has increased as NDHS revealed that 43% of people spent the night under (ITN) (Malaria Report, 2021).

9.3.1 Malaria Trend in the Geopolitical Regions

The trend of malaria incidence in all the geopolitical regions showed a general decline except in the North West (NW) as shown in Fig. 9.5. It also showed that it started growing all the geopolitical regions since 2016 except NW. In the north central (NC), there is a significant drop in the incidence of malaria as revealed in Fig. 9.5a with a 79.15% decline. However, there are fluctuations in the incidence in the study period with a rise in the years 2003, 2004, 2005, 2006 and 2007 with mean incidence rates of 449.8, 459.3, 487.9, 502.8, 505.5 and 498.9, respectively.

In the North East (NE), there is also a decline in the incidence, but the significance of the decline is a little above average with a 58.52% decline. There was a rise in the incidence from 2003 to 2008 with mean rates rising from 374.7 in 2002 to 384.6, 410.2, 430.9, 437.9, 436.9 and 426.3 in 2003, 2004, 2005, 2006, 2007, and 2008, respectively (Fig. 9.5b).

The situation in North West (NW) is different from other regions; generally there was no significant decline in the incidence of malaria by just 2.94% as presented in Fig. 9.5c. There was a decline in the mean incidence rate from 454.9 in 2000 to 404.6 in 2005. It started rising again from 2006 reaching a peak rate of 489.436 per 1000 in 2010. A very slow decline followed for 5 years to a rate of 463.124 per 1000 in 2015 and a more improved decline ensued till 2020 reaching a mean rate of 351.696 per 1000. In this region, household ownership of ITN reached slightly under 80% in 2015, its use among children under five, pregnant women, and the general public greatly improved, and intermittent preventive treatment in pregnancy (IPTp) coverage (2+ doses) reached 28% (MEASURE Evaluation, NMEP, and PMI/Nigeria, 2017).

In South East (SE), there was a rise in the mean incidence from 403.32 in 2002 to 450.834 in 2006. This was followed by drastic drop in the incidence rate to as low as 189.534 per 1000 in the year 2015; however, the rates stared rinsing again reaching 288.844 per 1000 in 2020 as revealed in Fig. 9.5d. Overall, there is a severe drop in incidence rates of 69% in the region.

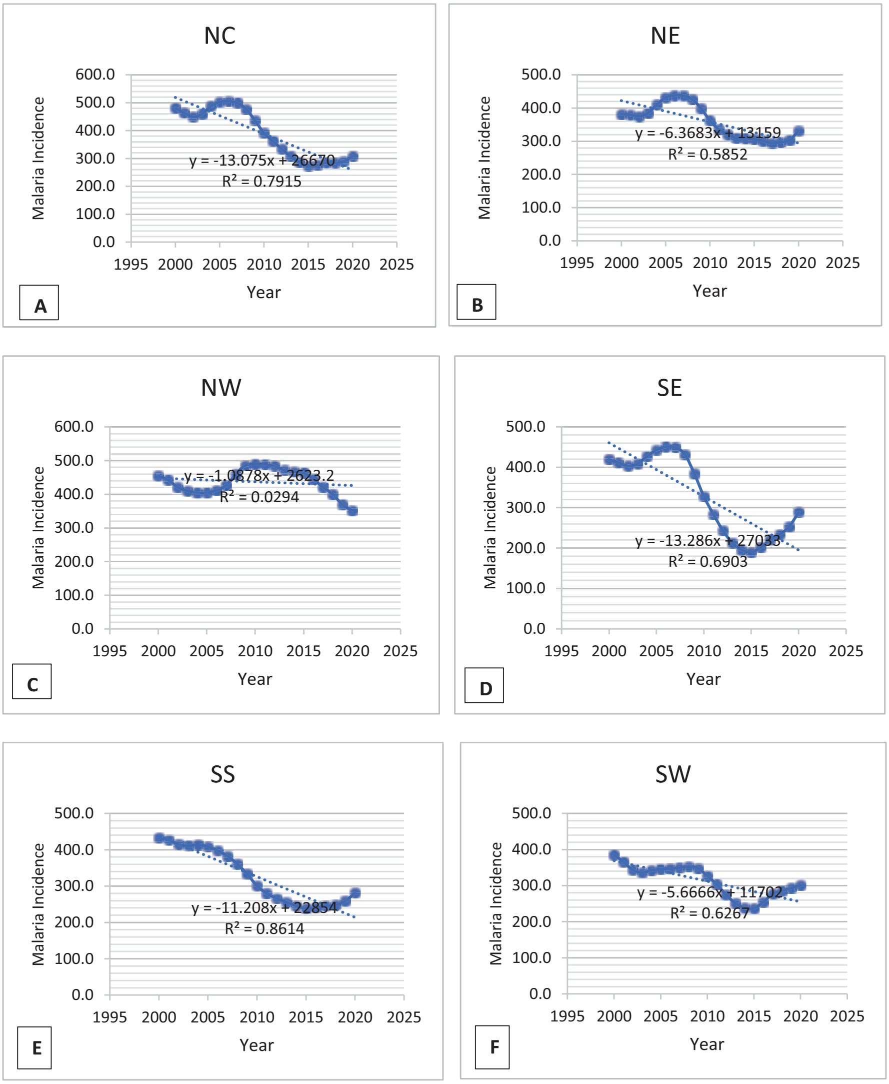

Fig. 9.5 Temporal distribution of malaria incidence in the geopolitical regions

The south-south (SS) region is the region with this highest percentage of decline in the incidence rate with 86% as shown by the trend line in Fig. 9.4e. The incidence rate dropped from 432.623 to 238.989 in 2015 per 1000 in 2000; it, however, started rising in subsequent years to 281.600 in 2020.

The mean incidence in South West (SW) increased from 335.99 in 2004 to 352.634 in 2008. This was after an earlier decline from 384.635 in 2000 to 342.198 in 2003. As seen in Fig. 9.5f, this was followed by a sharp decline in the incidence rate, which fell to 237.262 per 1000 in 2015 before rising once more to 312.16 per 1000 in 2020. Incidence rates have drastically decreased overall in the area by 62.7%.

From the forgoing, it was observed that the incidence overall has significantly reduced. However, there are variations between the geopolitical in the level reduction with SS reporting the highest percentage (86) and the lowest in NW (29/4). While the NDHS reported significant increase in the ownership of ITNs in NW, it is clear that other factors are responsible insignificant decline of malaria incidence in the region.

9.4 Environmental Determinants of Malaria

Any society's level of health is significantly influenced by its environment. Unfortunately, the environment has a particularly detrimental impact on health for the majority of underdeveloped nations. This is particularly true in Nigeria, where the environment was previously one of the health issues that received the least attention. The most important environmental factors for malaria transmission are temperature and rainfall, which have to do with the water in which Anopheles mosquitoes can breed and the minimum temperatures and humidity that allow them to survive long enough for the vector stage of the parasite's life cycle to be completed, which usually takes about ten days. These variables are impacted by the climate, terrain, soils, drainage, vegetation cover, land use, and water, all of which vary significantly according to regional conditions.

Since the vectors need specific habitats with surface water for reproduction, humidity is necessary for adult mosquito survival, and temperature affects the rates at which both the vector and parasite populations develop, malaria is essentially an environmental disease. This is consistent with Messina et al. (2011). Malaria is a vector-borne disease that is affected by climatic and geographic changes in the environment. The temporal and spatial distribution of malaria vectors and malaria has a significant impact on variables such as terrain, temperature, rainfall, land use, population movements, and degree of deforestation (FMoH, 2009; Oluleye & Akinbobola, 2010). Therefore, unique interactions among parasites, humans, vectors, and numerous environmental and anthropogenic variables lead to malaria. Rainfall, low height, and high temperatures, as well as the presence of shrubs and stagnant water close to homes, all encourage the growth of malaria vectors and the parasites that live inside of them (Messina et al., 2011).

The best rainfall, temperature, and humidity levels for anopheles mosquito breeding and survival are found in Nigeria (Efe & Ojoh, 2013). A rise in warmth and rainfall encourages mosquito development and improves mosquito breeding grounds, which increases the likelihood of malaria (Weli et al., 2015). In order for mosquitoes to transmit malaria, favourable environmental conditions like temperature must exist (20–30 °C). However, mosquitoes have a low probability of surviving in extremely cold or extremely hot conditions; they are fatal in temperatures below 5 °C and above 40 °C (in some instances, 35 °C) (Marj et al., 2008) relative humidity greater than 60%, topography less than 2000 m above sea level, and rainfall (mean monthly rainfall of more than 10 mm) (Amajoh, 1997).

Nigeria can be divided roughly into two regions: the south and the north. In the South-South, there are coastal wetlands; in the south-west, tropical rain forests; in the North-Central, open woodlands and grasslands; and in the far North-east and North-West, savannah and semi-desert. Nigeria, with its tropical environment, is ideally suited for mosquito breeding. It is endemic to the entire nation. Each region has a different level of malaria infestation. The Sahel regions and the Plateau's high mountain region both have slightly lower transmission rates. Generally speaking, malaria was more common in Northern Nigeria than it was in Southern Nigeria. This is partly explained by environmental and personal hygiene, which together with the climatic change make Nigerians and the health system more susceptible to infectious diseases like malaria.

The North West had a higher malaria prevalence than the South and South. Given that rainfall creates mosquito breeding grounds, it is anticipated that malaria transmission in the South-South region of Nigeria will be higher. The extreme humidity of the dry season and the stagnant water pools produced by the wet season's heavy and frequent rains all contribute to the ideal conditions for mosquito reproduction and spread (Orisakwe, 2011). The impact of climatic circumstances on the prevalence of malaria in the nation, however, may have been significantly modified by a number of additional factors, including education and poverty.

Additionally, the social context is crucial. According to the Malaria Indicator Survey (2015), the prevalence of malaria was 12% in rural areas compared to 36% in urban areas. Poor housing conditions and the low socioeconomic position of rural residents may be to blame for this. Urban residents frequently create their own artificial mosquito-breeding sites by improperly disposing of waste, allowing water to accumulate in cracks and containers around the home, and occasionally clearing bushes around residential areas. Rural residents are exposed to mosquitoes because of the vast expanse of natural vegetation and water bodies (Oladeinde, 2012). Sites created specifically for breeding vectors offer a favourable setting for vector growth. It is widely believed that in African metropolitan centres, artificial breeding facilities for vectors rather than natural ones provide the most plentiful sources of mosquito larvae (Castro et al., 2010; Chaki, 2009; Siri, 2010). Key factors affecting malaria transmission include hygiene, sanitation, and waste disposal. For instance, the more homes properly dispose of waste, the less likely it is that liquid waste will accumulate in stagnant water and create breeding grounds for vectors. Several investigations have shown the potential causes of foci of transmission, including environmental circumstances (Afrane et al., 2005; Sluydts et al., 2014). In the majority of Nigerian cities, trash is frequently carelessly dumped in open spaces, in city centres, in unfinished structures, and occasionally around homes, resulting in artificial mosquito breeding grounds (Orisakwe, 2011).

More typical habitats may be found in ditches and drains. In research done in Dar es Salaam, Tanzania, there were three times more drains and ditches that were anopheline-positive (Castro et al., 2010). Blockages, which are frequently the result of poor sanitation, decrease water flow and cause stagnant water pools to build up, which are perfect for mosquito breeding. Similar to this, gutters offer mosquitoes a place to spawn during both the wet and dry seasons, as was notably noticed by a study conducted in Abeokuta, Nigeria (Adeleke et al., 2008). Urban agriculture provides the most productive urban vector breeding sites, which is consistent with the findings that higher mosquito densities naturally lead to elevated levels of malaria transmission for people who either work on or live near urban agricultural fields, suggesting that malaria can be primarily driven by other local environmental factors such as land uses (Fournet, 2010).

According to a study by Oluyemi and Oyetunde (2019), certain environmental factors have a significant impact on the incidence rate of malaria in Nigeria over time and space. The study used data from the 2015 Malaria Indicator Survey, which covered 326 clusters across Nigeria's six geopolitical regions. In Nigeria, there was no appreciable change in the incidence rate of malaria between 2000 and 2005. However, a notable decrease in mean incidence was seen in 2010 (Table 9.3).

Although the mean incidence of malaria continued to significantly decline in 2015, all of the Northern areas had a considerable rise in aridity between 2010 and 2015. The wettest region in 2000 was the South-South. A decrease in rainfall and aridity was related in a direct manner. Lower mean rainfall was also observed in the drier Northern regions. The average rainfall patterns in the North East region did not significantly change between 2000 and 2015. In 2010, the South-South area had the highest mean precipitation, which was likewise the case in 2011.

9.5 Demographic Distribution of Malaria

Malaria typically has an equal impact on adults and children, but due to a variety of biological and cultural reasons, it has a more severe and lethal effect on young children and pregnant women (Kyu et al., 2013). This results from variations in innate immunity and resistance. Since malaria is transmitted by mosquito bites and has been an endemic disease in the nation for many years, the general adult population gradually builds up immunity and resistance, which lowers the disease's mortality and morbidity rates. However, gaining such protection requires time and comes after a number of malaria episodes. Particularly in regard to the most severe malarial strains, children under the age of five are less likely to have an adequate level of immunity. As a result, they experience higher-than-average rates of death and morbidity. Moreover, 50% of adults experience at least one episode of malaria each year, while children under five experience an average of 2–4 bouts per year (Samdi et al., 2012).

According to reports, among children under five years old in Nigeria, malaria is responsible for 30% of hospitalisations and 60% of outpatient visits (MIS, 2010). Each year, malaria is thought to claim the lives of 300,000 kids. Additionally, it is thought to be responsible for up to 11% of maternal deaths, 25% of baby deaths, and 30% of under-five deaths. Children under the age of five were probably more frequently affected by malaria cases that had fatal outcomes. Due to the endemic

Table 9.3 Variations in the mean malarial incidence rate and environmental factors in Nigeria (2000–2015)

Region	Year	Malaria incidence	Maximum temperature (°C)	Aridity (%)	Rainfall (mm)	Precipitation (mm)
North-central	2000	0.503 ± 0.076^{a}	32.389 ± 0.973^{b}	27.364 ± 5.831^{a}	1267.546 ± 156.595^{b}	109.973 ± 14.933^{a}
	2005	0.498 ± 0.061^{b}	32.571 ± 0.947^{b}	26.22 ± 4.634^{a}	1187.632 ± 140.722^{c}	103.717 ± 15.556^{b}
	2010	0.415 ± 0.109^{c}	33.016 ± 0.941^{a}	26.736 ± 5.985^{a}	1348.328 ± 134.733^{a}	107.707 ± 14.716^{ab}
	2015	0.387 ± 0.069^{c}	32.649 ± 0.966^{b}	22.598 ± 4.743^{b}	1184.479 ± 156.579^{c}	91.889 ± 13.082^{c}
North-east	2000	0.455 ± 0.078^{a}	33.77 ± 1.565^{c}	14.616 ± 7.62^{ab}	887.503 ± 370.037^{a}	72.482 ± 24.003^{a}
	2005	0.482 ± 0.077^{a}	34.526 ± 1.642^{ab}	15.944 ± 5.908^{a}	877.478 ± 300.362^{a}	79.214 ± 17.352^{a}
	2010	0.393 ± 0.087^{b}	34.757 ± 1.704^{a}	15.719 ± 6.507^{a}	909.753 ± 342.482^{a}	80.129 ± 18.389^{a}
	2015	0.364 ± 0.065^{b}	34.051 ± 1.584^{bc}	12.572 ± 5.859^{b}	882.297 ± 284.656^{a}	62.516 ± 17.136^{b}
North-west	2000	0.453 ± 0.115^{ab}	33.831 ± 1.348^{c}	11.857 ± 4.573^{b}	762.318 ± 276.245^{b}	64.966 ± 18.075^{b}
	2005	0.428 ± 0.092^{bc}	34.505 ± 1.324^{ab}	14.111 ± 4.87^{a}	808.942 ± 215.029^{b}	77.34 ± 17.991^{a}
	2010	0.476 ± 0.113^{a}	34.935 ± 1.301^{a}	13.599 ± 4.132^{a}	909.479 ± 271.744^{a}	75.53 ± 14.85^{a}
	2015	0.412 ± 0.089^{c}	34.13 ± 1.275^{bc}	10.09 ± 3.435^{c}	753.936 ± 212.556^{b}	55.264 ± 12.364^{c}
South-east	2000	0.448 ± 0.133^{a}	31.627 ± 0.253^{ab}	51.793 ± 6.446^{a}	2116.939 ± 279.463^{a}	165.393 ± 10.932^{a}
	2005	0.447 ± 0.115^{a}	31.541 ± 0.303^{b}	48.366 ± 7.53^{b}	1957.35 ± 344.272^{b}	150.984 ± 13.98^{b}
	2010	0.295 ± 0.088^{b}	31.748 ± 0.294^{a}	51.655 ± 9.055^{a}	2182.786 ± 330.793^{a}	168.111 ± 18.447^{a}
	2015	0.285 ± 0.083^{b}	31.721 ± 0.269^{a}	44.222 ± 7.402^{c}	1762.955 ± 232.558^{c}	146.53 ± 15.752^{b}
South-south	2000	0.449 ± 0.101^{a}	31.397 ± 0.200^{b}	58.175 ± 7.759^{b}	$2590.655 \pm 592.732^{ab}$	172.195 ± 16.292^{b}
	2005	0.388 ± 0.131^{b}	31.253 ± 0.209^{c}	56.564 ± 8.01^{b}	2411.414 ± 505.343^{b}	164.158 ± 17.919^{c}
	2010	0.304 ± 0.085^{c}	31.482 ± 0.258^{ab}	65.096 ± 7.114^{a}	2698.811 ± 610.783^{a}	196.391 ± 15.62^{a}
	2015	0.283 ± 0.073^{c}	31.511 ± 0.236^{a}	52.22 ± 8.050^{c}	2131.962 ± 417.486^{c}	161.662 ± 19.145^{c}

(continued)

Table 9.3 (continued)

Region	Year	Malaria incidence	Maximum temperature (°C)	Aridity (%)	Rainfall (mm)	Precipitation (mm)
South-west	2000	0.351 ± 0.154^{ab}	31.687 ± 0.455^{b}	33.611 ± 5.158^{b}	1352.185 ± 213.771^{b}	111.014 ± 14.541^{b}
	2005	0.375 ± 0.128^{a}	31.448 ± 0.43^{c}	32.291 ± 4.516^{b}	1318.17 ± 206.948^{b}	101.556 ± 11.173^{c}
	2010	0.349 ± 0.120^{ab}	31.887 ± 0.412^{a}	41.962 ± 6.087^{a}	1561.039 ± 221.844^{a}	135.169 ± 16.022^{a}
	2015	0.311 ± 0.112^{b}	31.776 ± 0.455^{ab}	29.371 ± 4.003^{c}	1298.87 ± 184.795^{b}	98.691 ± 10.864^{c}
Overall	2000	0.444 ± 0.121^{a}	32.498 ± 1.397^{b}	32.00 ± 18.449^{b}	1468.399 ± 736.554^{b}	113.937 ± 44.39^{b}
	2005	0.436 ± 0.112^{a}	32.705 ± 1.702^{b}	31.468 ± 16.835^{b}	$1403.174 \pm 651.458^{bc}$	111.353 ± 36.823^{b}
	2010	0.377 ± 0.120^{b}	33.044 ± 1.727^{a}	34.828 ± 20.02^{a}	1577.219 ± 738.002^{a}	124.939 ± 47.366^{a}
	2015	0.344 ± 0.097^{c}	32.694 ± 1.449^{b}	27.719 ± 16.544^{c}	1315.455 ± 546.891^{c}	100.779 ± 42.274^{c}

Source: Adapted from Oluyemi and Oyetunde (2019)

Note: Mean ± SD with different superscripts is significant at a 5% level with a > b > ab > bc > c prevalence of malaria in Nigeria, older children develop some immunity to the disease. However, young children under the age of five who have not yet developed immunity might experience severe forms of malaria.

Despite considerable geographical, rural-urban, and socioeconomic inequalities, microscopy data from the 2018 Nigeria Demographic and Health Survey (NDHS) revealed that the prevalence of malaria parasitaemia in children under five years of age is 23% (down from 27% in 2015 and 42% in 2010). The prevalence varies by region, from 16% in the South and South-East to 34% in the North-West. Given that rainfall creates mosquito breeding grounds, it is anticipated that malaria transmission in the South-South region of Nigeria will be higher. The impact of climatic circumstances on the prevalence of malaria in the nation, however, may have been significantly modified by a number of additional factors, including education and poverty.

Basically, data from the 2010 National Malaria Indicator Survey, as shown in Fig. 9.6, demonstrate variation in the regional spread of malaria.

Children under five were more likely to have malaria (slide positive rate) in the southwest of the country, where it was 50.3%, than in the southeast (NPC et al., 2012). Climate and biological variations in the various geopolitical zones provide simple explanations for the observed pattern of distribution. However, sociodemographic elements and differing health system conditions, especially program implementation, may also be responsible for these geographical variations. The Nigeria Malaria Indicators Survey (NMIS) 2010 found that there is still a significant parasite prevalence of malaria, with an average parasite prevalence of 42% among children under five years of age and zonal differences ranging from 27.6% in the South-east to 50.3% in the South-west region. Regional disparities may also be explained by sociodemographic variables, differing health system conditions, and program implementation.

As a result, both poverty and education have a big impact on how common malaria is in the nation. In 2015, malaria prevalence among children was 10 times higher among mothers in the lowest wealth quintile than it was among mothers in the highest wealth quintile, with rates of 42.9% and 4.4%, respectively. Malaria

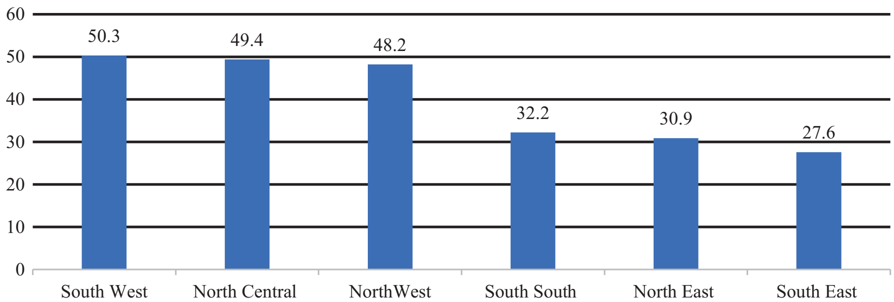

Fig. 9.6 Malaria prevalence among children under-five years by geopolitical regions. (Adapted from: United States Embassy in Nigeria (2011). Nigeria Malaria Facts Sheet)

disproportionately affects the poor and places a significant economic burden on nations. Malaria was prevalent in 37.7% of children whose mothers had no formal education, which is a measure of socioeconomic position; it was ten times more prevalent in children whose mothers had at least a secondary education.

9.6 Malaria in Pregnancy

Due to their lowered immunity, pregnant women are more vulnerable to contracting malaria since they may not be able to fight off illnesses like it as successfully (Bausernam et al., 2019). According to an analysis by the World Health Organization published in 2019, there were an estimated 11 million malaria-infected pregnant women in sub-Saharan Africa in 2018. This caused over 900,000 babies to be born each year with low birth weights, and malaria during pregnancy is to blame for 11% of all newborn fatalities and 20% of stillbirths in sub-Saharan Africa (WHO, 2018). In 2018, the West African sub-region and Central Africa (both with 35% prevalence) had the greatest rates of exposure to malaria infection in pregnancy, followed by East and Southern Africa (20%). The Democratic Republic of the Congo and Nigeria accounted for about 39% of the total.

In Nigeria, malaria is the primary cause of maternal mortality, making it a serious public health issue when it affects expectant mothers. The main malaria-related effects on pregnant women are low birth weight in neonates, a high placental plasmodia burden, foetal issues, and occasionally newborn death (Erhabor et al., 2010; Jenavine et al., 2015). The fact that malaria affects over 52% of pregnant women in Nigeria is another factor that contributes to maternal anaemia, low birth weight, stillbirths, abortions, and other malaria-related issues (Okpua et al., 2018).

Pregnant patients with severe malaria have a maternal death rate that is twice as high as those patients who are not pregnant. The most typical symptom, anaemia, typically appears in the second trimester of pregnancy. Except during pregnancy, cerebral malaria is uncommon in adults and is a major contributor to maternal malaria-related mortality. Serious falciparum malaria may disrupt normal placenta implantation and development or result in genital anomalies that make pregnancy impossible (Oladepo et al., 2010). First and second pregnancies are more likely to have malaria in pregnancy, and primigravidae had about double the prevalence of malaria as multigravidae (Brabin & Rogerson, 2001). Regardless of gravidity, age is a risk factor for pregnancy-related malaria, with younger pregnant women being especially vulnerable (Rogerson et al., 2000; Walker-Abbey et al., 2005). The sociodemographic characteristics of illiteracy, early maternal age, low educational status, unemployment, and low income are equally important in increasing the risk of malaria in pregnant women (Amuta, 2014; Umaru, 2015).

Up until now, reports of the prevalence of malaria during pregnancy have been inconsistent and high, particularly in South-West Nigeria, where rates range from 36.5% to 72% (Adefioye et al., 2007; Okwa, 2003; Anorlu, 2001). These data stand in stark contrast to those of Chimere et al. (2009), who found that pregnant women who visited prenatal clinics for the first time during their current pregnancy had a prevalence rate of 7.7%.

In research on malaria prevalence in pregnant women in Nigeria between 2007 and 2017, Etefia (2020) noted diversity across all of Nigeria's geopolitical areas. This demonstrates the significance of malaria as a significant problem for Nigeria's public health. It also causes substantial difficulties in pregnant women, which result in low birth weight in neonates, a high placental plasmodia burden, and foetal complications in addition to being the primary cause of the majority of mother and child deaths (Erhabor, 2010).

Similar to this, only a small fraction of pregnant women in all regions between the ages of 15 and 49 care enough to get at least one dosage of intermittent preventative treatment (IPT) while they are pregnant. In the North Western region, just 22% of patients received IPT (NHMIS, 2020). Consequently, 2020 saw the greatest death rate.

9.7 Conclusion

Even though the prevalence of malaria has significantly decreased since 2000, it still poses a hazard to the public's health in regions where the disease is endemic in the country. The prevalence of malaria varies across the nation, with the highest incidences recorded in the Northwest and the lowest in the Southwest. Since 2000, there have been some declines in occurrence across the country, with the south recording the greatest percentage and the north the lowest. This is as a result of a lot of malaria interventions in the country leading to improvement in the preventive measures such increased use of ITNs. The incidence of many states decreased significantly between 2000 and 2020. These decreases were most pronounced in the southern and north-central regions of the nation; however, there were also small but significant decreases in the more northern regions because the prevalence of malaria in the nation is significantly influenced by both poverty and education. Insecurity in parts of the country must have exacerbated the incidence especially in North Western Nigeria. Malaria in pregnancy is still high in southern and north central parts of the country.

In order for the worldwide goals of malaria reduction to be more realistically set, it is necessary to understand the causes of the changing patterns over time and among the various states and regions of this enormous country. To understand why infection patterns vary between states, more in-depth study on epidemiological factors and malaria prevention is required.

Reducing or possibly eradicating malaria is very essential because of its effects on humans in all parts of their live endeavours. The cost of malaria to an individual and their family may include the purchase of medications for treatment, travel expenses for seeking care at healthcare facilities, missed days at work and in school, costs associated with taking preventive measures, and other costs such as burial in the event of a death. The government is also spending a lot in provision of medications and supplies for the prevention of the disease. It is only in a healthy environment that development strives.

The present malaria control methods in country should be strengthened by educating Nigerians about the importance of improving their environment for malaria protection, empowering the public to improved their economy, and providing general education on how to prevent malaria infection. Since an integrated management strategy is thought to be the most effective for controlling malaria, it requires more consideration.

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Chapter 10
Antimicrobial Resistance in a Changing Climatic Context: An Emerging Public Health Threat in Africa

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10.1 Introduction

The prevalence of antimicrobial resistance (AMR) is growing, and by 2050, it is expected to be directly responsible for ten million deaths annually around the world (WHO, 2019). When compared to the existing yearly death toll of 700,000 owing to drug-resistant infections, this is a dramatic increase (Quintela-Baluja et al., 2015). Infectious diseases are responsible for over half of all mortality in developing nations (Clift, 2019), and efforts to reduce this number are being hampered by the rise of AMR (Allocks et al., 2017). It is a concern that developing nations (Ayukekbong et al., 2019), especially those in Africa, lack the surveillance and up-to-date knowledge necessary to prevent and cure drug-resistant infections.

Together, AMR and climate change present an even greater danger to humans, animals, and ecosystems in which they live. Increases in resistance of 2–4% and up to 10% for some drugs are predicted for *Escherichia coli, Klebsiella pneumoniae, and Staphylococcus aureus* if the daily minimum temperature climbs by 10 °C (McFadden et al., 2018). Rising sea surface temperatures have also been linked to an increase in cases of *Vibrio cholerae* (Pascual et al., 2000; Baker-Austin, 2013; Vezzuli et al., 2016; McFadden et al., 2018). Therefore, temperature may have an impact on the selection of antibiotic-resistant organisms at both the bacterial and human population scales, the transfer of resistant mobile components across bacteria, and the transmission of bacteria across species.

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Climate change is one of the main factors that have been linked to increased rates of AMR (Hani et al., 2020). There are a number of ways that climate change increases the prevalence of AMR. For example, higher temperatures can lead to more bacterial and viral infections in warm-blooded animals, including humans. This is because these organisms thrive in warmer conditions and can spread more easily through contact with other people, animals, or surfaces. Warmer climate also increases the number of pathogenic microorganisms that can grow in soil and water, which can further contribute to AMR. The AMR bacteria may develop, incubate, and reproduce more quickly with a slight temperature increase (Bradley, 1993). Moreover, the rate at which AMR pathogens interact with people can change depending on the temperature. The length of the transmission season can also change in response to a change in the temperature regime (Gubler, 2001). AMR pathogens may also alter their geographic spread to respond to temperature variations. In addition, epidemics of other infections (e.g., meningococcal meningitis) tend to erupt during the hot and dry season and subside soon after the beginning of the rainy season in sub-Saharan Africa (Moore, 1992).

Therefore, the rising temperatures in Africa that have outpaced the global average in recent decades (WMO, 2020) put Africa at risk for the unfavorable outcomes of AMR pathogens. This is due to the continent's high burden of climate-sensitive diseases as well as its inadequate institutional and community capacity to be ready for, adapt to, and respond to the effects of climate change (WMO, 2020). Rising temperature and shifts in precipitation can have an important effect on the spread of AMR infections across Africa. New illnesses are appearing in parts of Africa that were previously immune (WMO, 2020), leading to widespread usage of antimicrobials in the continent. Increasing temperatures are contributing to the proliferation of bacteria that resist antibiotic treatment, thus, referred to as antimicrobial resistance (Dadgostar, 2019). The prominent application of antibiotics in cattle farming, including in aquaculture, the widespread presence of human pathogenic bacteria, and the overall rising rates of microbial proliferation all contribute to this (Kaier et al., 2010; Babinszky et al., 2011). It will be more difficult and costly to treat illnesses as AMR spreads.

Understanding AMR trends in food animals is crucial since anecdotal evidence suggests that antimicrobials play a significant role in the health and production of food animals (2019). Antimicrobial use in animals is substantial and frequently exceeds that in humans. According to data, nearly 70% of antimicrobials sold in the EU in 2014 were for use in cattle (ECDC et al., 2017). AMR in zoonotic bacteria, which are the etiological agents of zoonoses and can be transferred directly between animals and humans or through the food chain, has been linked to the intake of antibiotics by both humans and animals (ECDC et al., 2017). An important topic of concern is AMR in zoonotic microorganisms. Despite the fact that AMR is a long-standing and naturally occurring phenomenon in some bacteria (D'Costa et al., 2011), the overuse of antimicrobials in people and animals, along with unsanitary working conditions and procedures in the food production chain, hastens the emergence of resistance in zoonotic bacteria (EFSA & ECDC, 2018). The growth in the prevalence of multidrug-resistant (MDR) zoonotic bacteria, which may degrade the response to antimicrobial therapy or possibly result in treatment failure, is a worrying consequence of AMR combined with the dearth of novel antimicrobials (WHO, 2014). *Salmonella* and *Campylobacter* resistance is seen as being of the utmost concern, according to the most recent report on AMR in zoonotic bacteria in 2016 (EFSA & ECDC, 2018). A zoonotic health risk is antibiotic resistance. Animals exposed to antimicrobial agents experience the emergence and spread of resistant microorganisms, just like humans do. Through the food chain or direct animal contact, resistant bacteria from animals can spread to humans and cause resistant illnesses. Therefore, it is imperative to review AMR studies of zoonotic origin from Africa.

Climate change has been reasonably disregarded (TLID, 2017), notably in Africa, despite WHO acknowledging some of the consequences of rising temperatures on a range of infectious diseases worldwide (McGough et al., 2020). In part, the lack of a proactive stance on climate change can be attributed to the fact that Africa is still grappling with effort to end the epidemics of infectious diseases, which is slowing down achievement of SDG goal 3.3 and African Agenda 2063 goal 3 that are geared toward having healthy and well-nourished citizens. This is worsened by emerging AMR diseases aggravated by changing climatic conditions as a result of global warming. Therefore, establishing prevalence of antimicrobial resistance in the midst of climate change across African countries is imperative at the research, policy, and practice levels. In this chapter, we employ systematic review technique to document status of AMR in Africa and discuss our findings in the context of public health approaches.

10.2 Methodology

The PRISMA-ScR Checklist on methods and reporting of results was followed. We compiled the information that has been published on the emerging antimicrobial resistance in Africa. Relevant articles published between 2010 and 2022 were rigorously searched for using Scopus, Web of Science, and Google Scholar. "Antimicrobial resistance," "antimicrobial resistance prevalence," "global warming," "climate change," and "Africa countries" were the phrases used in the search. About 2316 publications were retrieved from the database and through screening we narrowed down to 282 publications relevant to antimicrobial resistance and climate change in Africa. Following this initial phase of screening, the authors manually assigned codes to each observation.

We searched the titles and abstracts of all 2316 articles from 2010 until 2020 in the databases to discover studies that examined antibiotic resistance in Africa for this review. Only research studies that met the following criteria were included in this review: (a) It must have been conducted in Africa; (b) it must have estimated the prevalence or incidence of antimicrobial resistance pathogens; (c) it must have described at least some of the measures taken to prevent and/or control the spread of AMR pathogens; and (d) it must have reported quantitative or qualitative data of antimicrobial resistance pathogens in the humans and or domestic animals.

10.2.1 Selection Criteria

In total, 860 investigations were disregarded due to ineligible study locations or the presence of resistant microorganisms (viruses, protozoa, or helminths). Out of the 69 papers that made it beyond the initial title/abstract cut, 12 were unavailable online. Full-text analysis was performed on the remaining 57 studies. Following that, articles were filtered for studies which purely focused on resistance prevalence or incidence not mechanism. As a result, another 25 publications were excluded. Further 14 papers were omitted from the remaining 32 due to methodological issues, such as a lack of data regarding sample origin or inconsistent findings. Overall, the systematic review included 18 papers. Figure 10.1 shows the process flowchart for making selections and deciding which articles to keep.

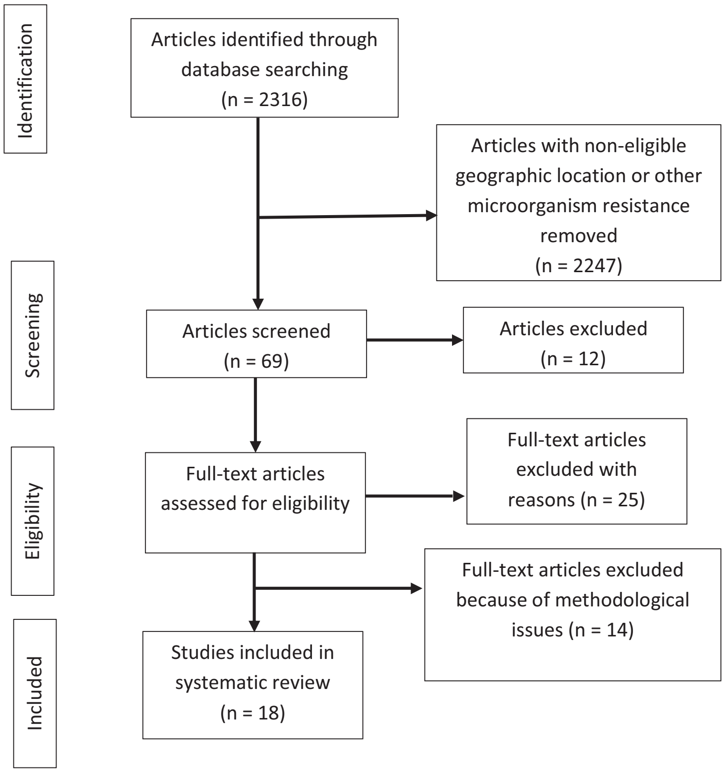

Fig. 10.1 Search strategy and PRISMA flow diagram

10.3 Results

10.3.1 Status and Trend of AMR in Africa

This review includes 18 primary studies that met the inclusion criteria, which are listed in Table 10.1. Despite the fact that the time range sought was from 2010 to 2022, the earliest study that met the requirements was released in 2015, and the number of studies published annually has increased in subsequent years (see Fig. 10.2). A total of 12 countries contributed in the studies: Algeria, Benin, Egypt, Congo, Ethiopia, Kenya, Ghana, Malawi, Sierra Leone, Rwanda, South Africa, and Tunisia, and data were included from eighteen bacterial genera: *Escherichia coli, Klebsiella pneumoniae, Enterobacteriaceae, Staphylococcus aureus, or Pseudomonas spp., gonococcal, Enterobacter cloacae, Salmonella typhi, Acinetobacter, Proteus, Streptococcus pneumoniae, Proteus Sp., Pseudomonus Spp., Campylobacter jejuni, Campylobacter coli, Campylobacter upsaliensis, Staphylococcus aureus, and Salmonella enterica*. About fifteen studies were of human isolate, three studies of poultry isolates, two studies of beef meat isolates, and one study each for dog and livestock isolates.

10.3.1.1 Human

Studies in seven African countries found that *Escherichia coli* from human isolates are resistance to 32 antimicrobials ranging from 27.0% to 98.9%, with Ticarcilin being the highest at 98.9% (Lakoh et al., 2020; Tornberg-Belanger et al., 2022; Ombelet et al., 2022; Mfoutou et al., 2021; Ntirenganya et al., 2015; Kumwenda et al., 2021; Agabou et al., 2016; Elhariri et al., 2020; Ramadan et al., 2020). Moreover, studies from other four African countries revealed that *Klebsiella spp.* from human isolates were resistance to 19 antimicrobials ranging from 17.0% to 100%, with ampicillin leading the pact at 100.0%. In the same studies, *Pseudomonas spp.* resistance to 12 antimicrobials were revealed at prevalence of 12.0% to 50.0% with Ciprofloxacin, Levofloxacin, Gentamycin, and Ceftazidime being the highest at 50.0% (Kumwenda et al., 2021; Lakoh et al., 2020; Ntirenganya et al., 2015; Tornberg-Belanger et al., 2022). Furthermore, two studies in Sierra Leone and Rwanda also found that *Acinetobacter spp.* from humans isolates had developed resistance to 17 antimicrobials ranging from 25.0% to 93.0%, and antimicrobials with notable resistance were Ampicillin and Trimethoprim/sulfamethoxazole at 93.0% each (Lakoh et al., 2020; Ntirenganya et al., 2015). Interestingly, *Enterobacter spp*. from human isolates had resistance to 15 antimicrobials ranging from 33.0% to 100.0% with Trimethoprim sulphamethoxazole at 100.0% (Lakoh et al., 2020; Lord et al., 2021; Ombelet et al., 2022).

In a Rwandan study, *Proteus* from humans' isolates were found to be resistance to eight antimicrobials ranging from 17.0% to 83.0%; more noticeable antimicrobial was gentamicin at 83.0% resistance (Ntirenganya et al., 2015), while

Table 10.1 Summary of antimicrobial resistance prevalence studies in Africa reviewed

Pathogen	Population	Prevalence/incidence	References	Country
Escherichia coli	Human	Aminoglycosides (34.4%), Amox/clav (93%); amoxicillin (41.75–98.9%); cefuroxime (40.8%); ampicillin (67.0–96.0%); aztreonam (70.0%, 89.3%); cefamandole (95.7%); cefazolin (73.0%); cefepime (62.0–87.2%); cefotaxime (31.0%, 92.5%); ceftazidime (33–82.9%); ceftriaxone (30.0–70.0%); cefuroxime (35–72.0%)); chloramphenicol (51%); otrimoxazole (31%); ciprofloxacin (66.0–74.4%); cotrimoxazole (85.1%); gentamicin (27–66.6%); imipenem (66.6%); levofloxacin (70.0%); mecillinam (72.3%); nalidixic acid (28%, 79.7%); norfloxacin (39%); ofloxacin (63.0%, 78.7%); penicillins (53.1%); piperacillin (97.8%); amoxicillin/clavulanic acid (80.8%); ticarcillin/clavulanic acid (88.3%); cefalotin (93.6%); piperacillin–tazobactam (51%); tetracyclines (34.4%); (98.9%); TMP/SMX (76%); tobramycin (50.0%); tobramycin (65.9%); trimethoprim sulphamethoxazole (82.0%).	Lakoh et al. (2020), Tornberg-Belanger et al. (2022), Ombelet et al. (2022), Mfoutou et al. (2021), Ntirenganya, et al. (2015), Kumwenda, et al. (2021), Agabou et al. (2016), Elhariri et al. (2020) and Ramadan et al. (2020)	Sierra Leone Kenya Benin Congo Rwanda Malawi Algeria and Egypt
	Poultry	Amoxicillin (78.5%); ampicillin (32%); azithromycin (50.8%); ceftriaxone (70.5%); Chloramphenicol (48.1%); ciprofloxacin (51.4%, 77.0%); cotrimoxazole (82.6%); Doxycycline (44.0%); enrofloxacin (32%); gentamicin (73.8%); Nalidixic acid (88.6%, 96.7%); ofloxacin; (80%); penicillins (98.4%); streptomycin (93.4%); sulfisoxazole (95.1%); tetracycline (96.7%); ticarcillin (78.5%); Trimethoprim/sulphamethoxazole (38.0%, 63.9%);	Agabou et al. (2016); Hassan et al. (2021) and Ramadan et al. (2020)	Algeria South Africa Egypt
	Dog	Penicillin-G (99%); clindamycin (100%); tylosine (95%); cephalothin (84%); enrofloxacin (16%); orbifloxacin (21%)	Qekwana et al. (2018)	South Africa
	Beef	Penicillins (37.0%); streptomycin (40.7%); trimethoprim/sulphamethoxazole (44.4%); sulfisoxazole (95.1%); tetracycline (44.4%); chloramphenicol (40.7%).	Ramadan et al. (2020)	Egypt
Klebsiella spp.	Human	Amox/clav (95%); amoxicillin-clavulanic acid (81.0%); Ampicillin (37.0%, 100%); aztreonam (69.0%); cefalothin (65%); cefazolin (71.0%); cefepime (58.0%); cefotaxime (44%); ceftazidime (58%, 65.0); ceftriaxone (55.0–77.6%); cefuroxime (68–79.3); ciprofloxacin (65–70.7%); gentamicin (27–74.1%); levofloxacin (90.0%); Norfloxacin (46%); ofloxacin (17%); TMP/SMX (84%), Tobramycin (33.0%); trimethoprim sulphamethoxazole (84.0%);	Lakoh et al., (2020), Ombelet et al. (2022), Ntirenganya, et al. (2015) and Kumwenda, et al. (2021)	Sierra Leone, Benin, Rwanda Malawi

Pathogen	Population	Prevalence/incidence	References	Country
Pseudomonas spp.	Huma	Ciprofloxacin (50.0%); levofloxacin (50.0%); gentamycin (50.0%); tobramycin (43.0%); ceftazidime (50.0%); Aminoglycosides (42.1%); piperacillin (33%); ceftazidime (33%); ciprofloxacin (67%); gentamicin (26%); ciprofloxacin (12%)	Lakoh et al., (2020) Tornberg-Belanger et al. (2022), Ntirenganya, et al. (2015) and Kumwenda, et al. (2021)	Sierra Leone Kenya, Rwanda Malawi
Acinetobacter spp.	Huma	Ampicillin (36.0%, 93.0%); cefazolin (92.0%); cefepime (29.0%), cefotetan (69.0%); ceftazidime (33%, 46.0%); Ceftriaxone (36.0%, 40%); cefuroxime (50%); iprofloxacin (25%, 36.0%); gentamicin (33%, 56.0%); levofloxacin (40.0%); moxifloxacin (33.0%); nitrofurantoin (84.0%); Ofloxacin (33%); piperacillin (33%); tetracycline (80%); TMP/SMX (84%); trimethoprim/sulfamethoxazole (93.0%);	Lakoh et al., (2020) and Ntirenganya, et al. (2015)	Sierra Leone Rwanda
Enterobacter spp.	Human	Aztreonam (50.0%); Cefazolin (89.0%), Cefuroxime (72.7%); Cetriaxone (70.5%); Chloramphenicol (65.9%) Ciprofloxacin (33.0%, 75.0%); Extended-spectrum cephalosporins (3rd and 4th generation) (52.9%); folate pathway inhibitors (83.7%); gentamicin (67.0%, 68.2%) Penicillin/-lactamase inhibitor combinations (91.2%); phenicols (55.6%); penicillins (67.6%); quinolones and fluoroquinolones (30.0%); tetracyclines (50.0%). Tobramycin (44.0%); trimethoprim sulphamethoxazole (76.7%, 100.0%)	Lakoh et al. (2020), Lord et al. (2021) and Ombelet et al. (2022)	Kenya, Benin
Proteus	Human	Ampicillin (71%); Amox/clav (71%); cefuroxime (57%); ceftazidime (50%); ceftriaxone (17%); ciprofloxacin (67%); ofloxacin (67%); gentamicin (83%), chloramphenicol (58%); cotrimoxazole (24%); gentamicin (17%); nalidic acid (41%); ciprofloxacin (9%)	Ntirenganya, et al. (2015)	Rwanda
Staphylococcus aureus	Human	Cefalothin (71%); cefuroxime (60%); ciprofloxacin (33%); erythromycin (33%, 50%); fluoroquinolones (56.7%); norfloxacin (33%, 67%); ofloxacin (27%, 40%); oxacillin (82%, 100%); penicillin (67–90.0%); tetracycline (35.0–71.0%); trimethoprim-sulfamethoxazole (70%)	Lord et al. (2021), Ntirenganya, et al. (2015), Kumwenda, et al., (2021) and Egyir et al. (2020)	Kenya, Rwanda, Malawi, Ghana
	Meat	Ampicillin (59.5%, 76.5%), clindamycin (74.3%, 77.9%), erythromycin (60.3%), penicillin (52.7%), penicillin (83.8%), rifampicin (41.9%), rifampicine (69.1%), tetracycline (82.4%),	Jaja et al. (2020)	South Africa
	Livestock	Penicillin (53.0%), tetracycline (47.0%), ciprofloxacin (47.0%), clindamycin (20.0%)	Egyir et al. (2020)	Ghana

(continued)

Table 10.1 (continued)

Pathogen	Population	Prevalence/incidence	References	Country
Streptococcus pneumoniae	Human	Chloramphenicol (8%); cotrimoxazole (4%); gentamicin (40%); erythromycin (12%); ciprofloxacin (13%)	Kumwenda, et al. (2021)	Malawi
Gonococcal spp	Human	Ciprofloxacin (78%); tetracycline (74%); penicillin (33%); azithromycin (15%)	Maduna et al. (2020)	South Africa
Salmonella Typhi	Human i	Ampicillin (30.2%); trimethoprim-sulfamethoxazole (39.6%); chloramphenicol (39.6%)	Ombelet et al. (2022).	Benin
Salmonella enterica	Human	Ampicillin (88.8%), ceftriaxone (66.6%), ceftazidime (77.7%), and imipenem (66.6%).	Elhariri et al. (2020)	Egypt
	Poultry	Ampicillin (100%), ceftriaxone (91.6%), ceftazidime (87.5%), and imipenem (75%).		
gram-negative sepsis	Human	Ampicillin (95%); cefotaxime (87%); gentamicin (85%); AmpGen (85%); piperacillin-tazobactam (39%); amikacin (8.4%)	Solomon et al. (2021)	Ethiopia
Campylobacter jejuni	Human	Amoxicillin/clavulanic acid (66.6%); ampicillin (60.6%); tetracycline (36.3%); tigecycline (36.3%); cephazolin (62%); cefuroxime (50%)	Chukwu et al. (2019)	South Africa
	Poultry	Ampicillin (73.6%); Amoxicillin/acid clavulanic (52.7%); ciprofloxacin (98.9%); nalidixic acid (57.1%); erythromycin (100%); tetrac ycline (100%); chloramphenicol (83.5%); gentamycin (14.3%)	Gharbi et al. (2018)	Tunisia
Campylobacter coli	Human	Clarithromycin (35.5%); erythromycin (35.5%) amoxicillin/clavulanic acid (61%); ampicillin (62.7%); tetracycline (32.2%); tigecycline (32.2%); cephazolin (59.3%); cefuroxime (62.7%)	Chukwu et al. (2019)	South Africa
Campylobacter upsaliensis	Human	Amoxicillin/clavulanic acid (68%); ampicillin (68%); cephazolin (56%); cefuroxime (44%)	Chukwu et al. (2019)	South Africa

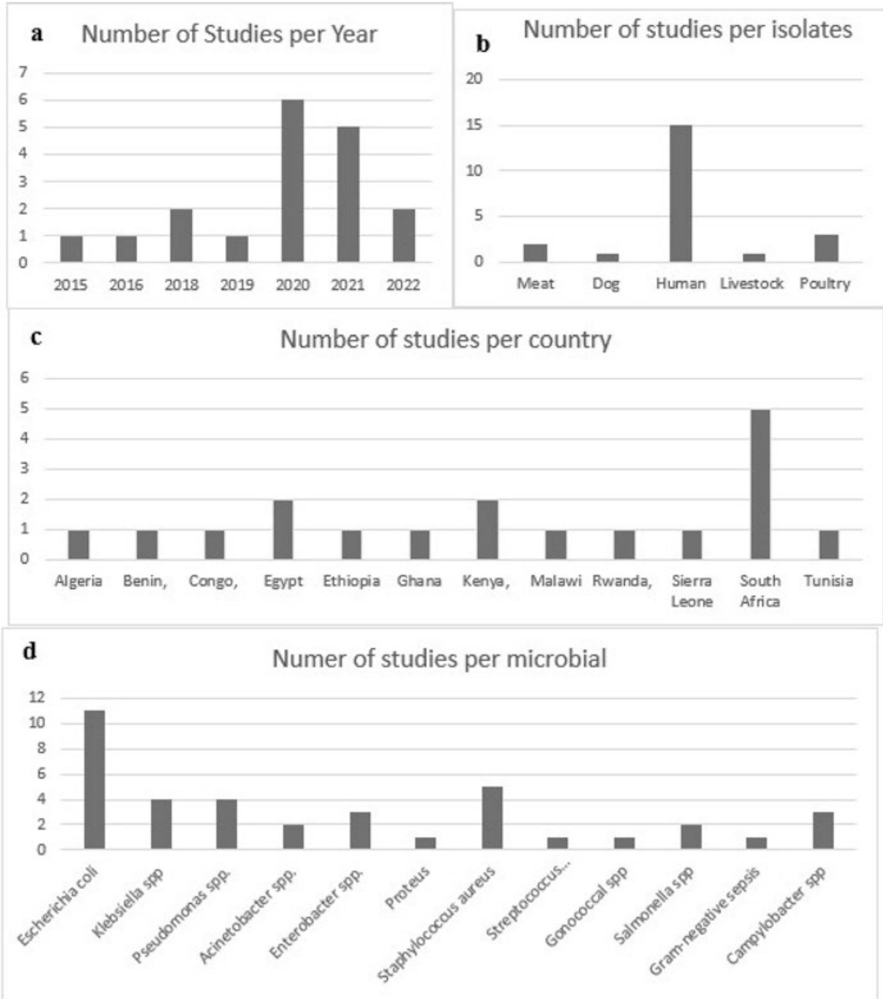

Fig. 10.2 Summary of the selected studies showing number of studies (**a**) per year, (**b**) per isolates, (**c**) per country, and (**d**) per microbial

Staphylococcus aureus from human isolates had also shown resistance to 11 antimicrobials ranging from 33.0% to 71.0% with Cefalothin standing out at 71% (Egyir et al., 2020; Kumwenda et al., 2021; Lord et al., 2021; Ntirenganya et al., 2015).

In Malawi, *Streptococcus pneumoniae* isolated from humans were found to be resistant to four antimicrobials albeit low at 4–40% with gentamicin leading at 40.0% (Kumwenda et al., 2021). Additionally, *Gonococcal* from human isolates were reported to have resistance to 4 antimicrobials ranging from 15.0% to 78.0% with having the highest resistance on Ciprofloxacin (Maduna et al., 2020). However, *Salmonella typhi* from human samples in Benin had the lowest antimicrobial resistance (30–39.6%) to the three antimicrobials compared to other resistance from other microbes (Ombelet et al., 2022). In contrast, level of resistance in *Salmonella enterica* was significantly high among the four antimicrobials ranging from 66.6% to 88.8% with resistance to Ampicillin topping (Elhariri et al., 2020).

In Ethiopia, *gram-negative sepsis* from the newborns was found to be resistance to six antimicrobials with percentages ranging from 39.0% to 95.0%. Ampicillin was the highest among other antimicrobials (Solomon et al., 2021). Equally, *Campylobacter jejuni* was also found to have develop resistance to six antimicrobials ranging from 36.3% to 66.6% in South Africa, with it being less susceptible to Amoxicillin/clavulanic acid (66.6%) (Chukwu et al., 2019). *Campylobacter coli* and *Campylobacter upsaliensis* have also been shown to have developed resistance to eight and three antimicrobial agents, respectively. This South African study further reveal that both *Campylobacter coli* and *Campylobacter upsaliensis* were more resistant Ampicillin at 62.7 and 68, respectively (Chukwu et al., 2019).

10.3.1.2 Domestic Animal

The increased likelihood of AMR transmission is caused by farmers' and animal health workers' direct or indirect contact with animals. There are many ways for zoonotic infections to spread from animals to people. But the food chain is the most likely pathway for transmission (Dafale et al., 2020). Animal-derived foods such milk, eggs, meat, and protein put humans at increased risk of exposure to AMRs that are of animal origin. For this review, poultry isolates from studies in three countries indicate that *Escherichia coli* is resistance to 18 antimicrobials ranging from 38.0% to 98.4%, with resistance being highest toward Penicillin (98.4%) (Agabou et al., 2016; Hassan et al., 2021; Ramadan et al., 2020). While in Egypt study, *Salmonella enterica* from poultry isolates were found to be resistant to four antimicrobials with value ranging from 75.0% to 100%, Ampicillin being at 100% (Elhariri et al., 2020). In Tunisia, *Campylobacter jejuni* found in poultry were found to be less susceptible to seven antimicrobials with resistance percentages ranging from 52.7% to 100.0%, having Erythromycin and Tetracycline as agents they are more resistant to (Gharbi et al., 2018).

On the other hand, *Escherichia coli* isolates from both dog and beef were found to be resistance six antimicrobials each ranging from 16.0% to 100.0% and 37.0% to 95.1%, respectively, while resistance to Clindamycin was highest (100.0%) in dogs' isolates and Sulfisoxazole (95.1%) in beef isolates (Qekwana et al., 2018; Ramadan et al., 2020). In South Africa, *Staphylococcus aureus* from meat isolates were reported to have resistance to 9 antimicrobials ranging from 41.9% to 83.8% with Penicillin having the highest resistance (83.8%) (Jaja et al., 2020). In another study in Ghana focusing on livestock, *Staphylococcus aureus w*as found to be resistance to four antimicrobials with Penicillin having highest resistance at 53.0% (Egyir et al., 2020).

10.4 Discussion

This systematic review examined studies on AMR in *Escherichia coli, Klebsiella, Pseudomonas, Pseudomonas, Acinetobacter, Enterobacter, Proteus, Staphylococcus, gonococcal, Salmonella, and Campylobacter species* in Africa. It focused on included studies involving human and domestic animal isolates from 12 countries in Africa.

10.4.1 Antimicrobial Resistance Prevalence in Africa

There was high prevalence of resistance observed in all antimicrobial used for the treatment of the 11 microbes, with an exception of *Streptococcus pneumoniae*, which had the lowest resistance prevalence (4–40%) (Kumwenda et al., 2021). For example, *Escherichia coli* was found to be associated with resistance to 32 antimicrobials resistance in both human and animals (Lakoh et al., 2020; Tornberg-Belanger et al., 2022; Ombelet et al., 2022; Mfoutou et al., 2021; Ntirenganya et al., 2015; Kumwenda et al., 2021; Agabou et al., 2016; Elhariri et al., 2020; Ramadan et al., 2020).

Other research studies have also shown the significant amounts of resistance to widely used antimicrobials including ampicillin, tetracyclines, and trimethoprim/sulfamethoxazole that are shown in this review (Eguale et al., 2016; El-Sharkawy et al., 2017; Eguale et al., 2017; Kimera et al., 2020). Antimicrobial resistance (AMR) genes that confer resistance in animals and humans are a major cause for concern. The widespread use of tetracycline in livestock production may explain the high prevalence of resistance to this drug (Mitema et al., 2001); in addition, the use of sulfamethoxazole-trimethoprim and chloramphenicol as first-line therapeutics for typhoid (GARPK, 2011; MMS & MOPHS, 2010a) and the prophylactic use of sulfamethoxazole could have contributed to development of their resistance (Kohli et al., 2010; Muvunyi et al., 2011; Maina et al., 2012; MMS & MOPHS, 2010b; Rogawski et al., 2017).

This review reveals that *Escherichia, Klebsiella, and Staphylococcus species* are resistance to 32, 19, and 9 antimicrobials, respectively, in both domestic animals and humans. This could also be partially attributed to increase temperature and population density in some part of African countries. For example, the antibiotic-resistant *Escherichia, Klebsiella, and Staphylococcus* cases have previously been demonstrated to increase by 2–4% with increase in local temperature (MacFadden et al., 2018). There is a direct relationship between rising temperatures and the spread of infectious diseases, including AMR diseases (MacFadden et al., 2018). The spread of AMR in many bacterial species that are crucial to human health may be influenced by climate change factors, such as rising air temperatures and increased urban density, even though selective pressure from antibiotic use is thought to be the primary cause of the emergence of antibiotic resistance (Beck et al., 2018; Güneralp et al., 2017). For example, cholera infections are expected to increase in the near future as a result of temperature, precipitation, and sea level dynamics (D'Souza et al., 2004). Similar to this, Salmonella that causes food poisoning multiplies quickly at higher temperatures, and changes in eating habits may also have an impact on exposure (D'Souza et al., 2004). The current status of some infectious diseases in Sub-Saharan Africa as a result of variations in regional temperature and changes in the seasonal and inter-annual patterns of some enteric pathogens, such *Cholera* and *Salmonella*, is another indication of the effects of climate change on the dynamics of infectious disease (Woodward & Macmillan, 2015). This review shows that the issue is getting worse, as *Salmonella species* in both animals and humans are becoming resistant to routinely used antibiotics as Ampicillin, Trimethoprim-sulfamethoxazole, and Chloramphenicol.

AMR is also likely to become more common in Africa due to climate change. This is because warmer temperatures allow bacteria to grow more rapidly, and they are able to resist antibiotics more easily. In addition, AMR is becoming increasingly resistant to existing antibiotics, so new antibiotics are needed more often to treat infections.

10.4.2 Challenges to Public Health Approach to Control of Antimicrobials in Africa

10.4.2.1 Health Facility Challenges

Because most healthcare facilities in Africa have limited laboratory capacity, most infections are treated without proper diagnosis (Luvsansharav et al., 2020). Consequently, the spread of antibiotic resistance is aided, and the outcomes of patient care are diminished as a result. Self-medication is also common in low-income metropolitan areas since it is seen to be cheaper than visiting a doctor, especially in areas where infectious diseases are common and access to healthcare is limited. The rapid spread of AMR is exacerbated by the easy access to antibiotics in the region's densely populated informal settlements, where antibiotics are frequently misused and overused (Mekuria et al., 2019; Othieno et al., 2020). AMR is becoming increasingly problematic, and this is made worse by the availability of fake medications, their entry into African countries through open borders, and the ineffective enforcement of laws designed to ensure the supply of high-quality medications.

10.4.2.2 Suboptimal Antimicrobial Resistant Surveillance

It is challenging to predict how antimicrobial use and resistance are trending in relation to the implementation of policies because AMR surveillance is lacking in agriculture and food production sectors. Studies that have looked at antibiotic resistance in agriculture and the food industry have found that it is a growing problem. Therefore, it is important to have laws and regulations in place, along with a plan for enforcing them. The connection between resistance in animals, humans, and the environment remains poorly understood in the continent, and competing priorities, high costs, and low awareness all contribute to the AMR problem. Antimicrobial resistance and the overuse of antibiotics in agriculture and food production are serious problems that Africa must address through the introduction of new laws on concerted efforts on behavior change. Prescription guidelines, antimicrobial usage and resistance tracking, antimicrobial waste management, and strengthening national drug regulatory bodies are all aspects that need attention in the realms of agriculture, human health, and animal health. Among these regulations, the outright ban on retail sales at the point of sale is warranted.

10.4.2.3 Poor Water, Sanitation, and Hygiene Services

African countries carry a substantial burden of water-, sanitation-, and hygiene (WASH)-related diseases that are commonly treated with antimicrobials (Araya et al., 2016). The majority of patients will take an antibiotic for viral diarrheal illnesses, and some of these will be self-medicated. It is argued that if developing nations had better access to WASH services, antimicrobials use would drop by 60% (O'Neill, 2016). Moreover, due to human overuse of antimicrobials, excreta continue to serve as the principal source of both antimicrobial drugs and resistance genes (Singer et al., 2016). As a result, the transmission of AMR pathogens in the environment can be facilitated by a lack of proper sanitary facilities and basic hygiene habits.

Human and animal waste that may include AMR pathogens is often dumped in landfills without regard to its potential to contaminate water supplies. Wastewater treatment plants are often not designed to deal with antimicrobial residues and resistant organisms (Manaia et al., 2018). Water bodies may be contaminated with AMR pathogens due to the discharge of treated wastewater into the environment. Hospitals are a major contributor to antibiotic resistance due to their high antimicrobials use and the subsequent high amounts of antimicrobial residues in wastewater released into the environment (Riaz et al., 2020).

Due to inefficient absorption of antibiotics in the gastrointestinal tract, animal feces tend to have large quantities of antibiotic residues since they are not exposed to subsequent treatment like human wastes. As a result, a great deal of antimicrobial-resistant genes are discharged into the environment, particularly water bodies, due to the careless disposal of wastes from domesticated animals and cattle (Singer et al., 2016). There is growing evidence that livestock in underdeveloped countries, where animals are kept in isolation for security and other reasons, are harboring AMR bacteria (Palmeira & Ferreira, 2020).

Given the state of WASH infrastructure and behavior today, developing countries are likely to continue to be highly polluted for some time. For this reason, it is crucial to accelerate WASH interventions (both infrastructure and behaviors) in order to curb the spread of resistant organisms and genes in the environment and hence reduce the prevalence of diarrheal disorders. Water, sanitation, and hygiene (WASH) interventions focus on providing safe water, soap, and play areas for children (Araya et al., 2016). Human and animal waste poses a threat to water supplies because of the potential for the introduction of resistant microorganisms. Unless the water is purified sufficiently, it can harbor these resilient microorganisms, putting people at risk whether used for drinking, washing, or other household purposes (Singer et al., 2016).

Therefore, it is crucial to ensure the proper disposal of wastes generated within healthcare facilities in order to stop the spread of infectious diseases and the development of bacteria resistant to antibiotics (Musoke et al., 2021). Microorganisms in wastewater, including *E. coli, Shigella spp., Klebsiella spp., Salmonella spp., Acinetobacter spp., Vibrio spp., and Enterococcus spp.,* are increasingly resistant to antibiotics. As the number of people infected by these pathogens increases, so does the demand for antimicrobials; nevertheless, their misuse can lead to the development of resistance (Musoke et al., 2021).

10.5 Conclusion and Way Forward

Our results show that regional consumption drives selection for the carriage of genes conferring resistance to most antimicrobials. Due to the diverse patterns of resistance seen in the isolates and the prevalence of AMR in the wake of climate warming in Africa, it is necessary to establish infection control/prevention strategies and public health policies that are more effective and targeted than those currently in place in the community being studied. Second- and third-line antimicrobials are typically out of reach for African nations, making timely public health interventions to combat emerging sources of resistance unfeasible.

The failure of many African countries to effectively implement existing policies and legislation, most notably the prohibition of over-the-counter antimicrobials, highlights the importance of establishing or strengthening regulatory capacity to monitor AMR in agriculture and food production systems across the continent. Alternate strategies that help lower the need for antimicrobials should be promoted as well. Vaccination, biosecurity, and increased cleanliness are all examples of effective approaches to reducing AMR diseases. It is also conceivable that probiotics, prebiotics, and phytobiotics will replace antibiotics as growth boosters in animals used for food production. If the concerns on AMR are resolved, a reliable system can be put in place to assure the implementation of policies. Actions at the national, regional, and global levels are needed to combat AMR in all settings, and it will be easier if they are developed with the One Health concept in mind.

Building or increasing regulatory capacity to monitor AMR in agriculture and food production systems in Africa is important because many African countries have a hard time implementing existing norms and legislation, such as the ban on over-the-counter antimicrobials. Promoting other strategies to limit antibiotic use is equally important. These include things like larger-scale immunization drives, more stringent biosecurity precautions, and improved sanitation practices.

To address the African concerns of antimicrobial resistance, it is essential to increase knowledge and awareness of antimicrobial resistance and to encourage expert-driven behavioral change through effective communication, education, and training. The appropriate use and prescription of antibiotics must be addressed to target audiences in human health, animal health, agricultural practice, as well as consumers. It will be easier to ensure correct understanding and awareness among professionals if antimicrobial resistance is made a central part of professional education, training, certification, continuing education, and development in the health and veterinary sectors as well as agricultural practice.

Lastly there is need to improving public health education about climate change and infectious diseases. This can be achieved through developing new public health strategies for addressing climate change and infectious diseases together. This includes developing plans for how communities can adapt when extreme weather events become more common and also working on ways to educate the public about the dangers of infection and how they can protect themselves.

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Part III
Health and Wellbeing

Chapter 11
Climate-Related Diseases and Health Impacts of Climate Change in Sub-Saharan Africa

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11.1 Introduction

Climate change is a leading public health concern of the twenty-first century and has implications for population health globally. Climate change is the term used to describe long-term variations in temperature and weather patterns. Natural alterations, like variations in the solar cycle, may have caused these changes. However,

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since the 1800s, human activities—primarily the use of fossil fuels like coal, oil, and gas—have been the main driver of climate change (United Nations, 2022). Indicators are used to identify the rate of climate change in regions. Some of these indicators are greenhouse gas concentrations, the global annual mean temperature, ocean heat, ocean acidification, global mean sea level, heat wave, flooding, drought, and ozone hole (World Meteorological Organization (WMO), 2022). Temperature was the primary indicator used in the 2015 Paris agreement signed by world leaders. The agreement's main goal is to limit global temperature rise to 2 °C by 2100 and to pursue efforts to limit the rise to 1.5 °C (Fawzy et al., 2020). According to Allan et al. (2021), unless there is a deep reduction in carbon oxide and other greenhouse gas emission in the coming decades, global warming of 1.5 °C and 2 °C will be exceeded during the twenty-first century (Allan et al., 2021).

Carbon dioxide and other greenhouse gas emissions, deforestation, and other anthropogenic activities have significantly contributed to the worsening effects of climate change on the environment and humans. The world experienced about 315 natural disasters in 2018, majority of which were caused by climate change. Furthermore, the most vulnerable sectors to climate change have been identified as food, water, health, ecosystem, human habitat, and infrastructure with Africa identified as the most vulnerable region to climate change impact (Sarkodie & Strezov, 2019). Many parts of Southern Africa are expected to become drier and hotter as some regions of the continent (such as Eastern Africa) are forecast to see direct effects that are very different (Collier et al., 2008). The Sub-Saharan coastal regions will be notably affected as the daily rainfall intensity is anticipated to increase under more extreme global warming scenarios (Weber et al., 2018). According to observed rates and model forecasts, the rate of warming across Southern Africa is double that of the rest of the world (Chersich et al., 2018; Engelbrecht et al., 2015).

There has been observed change in the climate of Nigeria with increased temperature, variable rainfall, increased sea level and flooding, drought and desertification, land degradation and frequent extreme weather event (Haider, 2019). There has been an increase in the duration and intensity of rainfall experienced in Nigeria in recent times. Precipitation is expected to increase in southern areas, and rising sea levels are expected to exacerbate flooding and submergence of coastal lands (Dike et al., 2020). Since the 1980s, temperature has risen significantly. Climate projections for the next few decades show a significant increase in temperature across all ecological zones (Akinsanola & Ogunjobi, 2014; Akpodiogaga-a & Odjugo, 2010).

In Kenya, the existence of climate change is observable through the seasonal changes in precipitation and temperature of varying intensity and duration. With rising temperatures and less consistent rainfall due to climate change, Kenya will likely see more floods and droughts. The average annual temperature is predicted to increase by 0.8–1.5 °C by the 2030s and by 1.6–2.7 °C by the 2060s, according to statistics from Global Climate Modelling (GCM) (Esho et al., 2021). The impact of the increased temperature leading to less consistent rainfall has resulted in the prevalence of drought in some regions of the country. From the foregoing, and due to negative direct consequences and a limited capacity for adaptation, Africa is very likely to experience severe repercussions from climate change. This chapter looks at some of these repercussions as they relate to population health in Africa. It specifically focuses on the relationship between climate change, disease, and health outcomes in Africa using examples from studies in Nigeria, Kenya, and South Africa among others.

11.2 Climate Change and Health

Scientific evidence, increasing substantially over the past two decades, shows that weather, climate and climate change are affecting human health. There is a complex and intricate relationship between human health issues and environmental changes with consequential reactions. According to Abisha and Sasilatha (2016), Malikabood et al. (2016), and Sarry El-Din et al. (2012), climate change has several negative consequences cutting across nearly all spheres of life, particularly urban livability and human health, either directly or indirectly. This follows from its effects on both the social and environmental determinants of health such as clean air, safe drinking water, food, and shelter. The environment is the principal part of all human existence, and the major impacts of climate change are situated here. There is evidence that the rise of CO_2 levels has led to much human suffering, including malnutrition-related illnesses, increased incidences of death, disease, and injuries.

While greenhouse gases emissions pollute the air, effluents discharge from homes and industrial site, and melting glaciers, rising sea levels, and their attendant effects on flooding make water unsafe for drinking. Glacier melting and rising sea levels are consequent upon global warming. Changing rainfall pattern and rising temperatures, as well as deforestation, impact food production, while changing land use and other natural disasters precipitated by human activities in the environment threaten safe shelter. Heat waves result in heat stress, exhaustion, and stroke, along with occupational heat challenges, with significant impacts particularly for those with chronic illnesses. Increased precipitation with catastrophic rain events, flooding, and hurricanes are occurring more frequently along with subsequent death, injuries, and disability.

Other health consequences linked with climate change also include air quality issues that impact respiratory and cardiac health, aeroallergens due to lengthy pollen seasons with high ambient temperatures, and diseases carried by vectors that include lyme disease, malaria, zika, and others. Food and waterborne illnesses are increasing due to climate change, as well as diarrheal disease and food insecurity. Floods from rising sea levels are a challenge for coastal dwellers, and heat stress and heat stroke from extreme temperatures are increasingly common. Wildfires from high ambient heat, described as challenging in areas of Africa and globally, is another example of health consequences in our climate-changing world. Several factors and determinants such as biological or genetic composition, environmental factors, and socio-economic conditions touched by the effects of climate change certainly have a high impact on the health status of the society (Thompson et al., 2012).

Wide ranging and possibly dangerous effects on health caused by climate change are either directly (such as through heat waves and natural disasters) or indirectly (through the disturbance of intricate ecological processes, for example, changes in patterns of infectious diseases, in fresh water supplies, and in food production) (Raimi et al., 2018). Health risks from climate change will significantly affect the vulnerability of individuals, communities, and health systems with thousands of peoples health denied (Allan et al., 2021). Around the world, health risks are unevenly distributed within regions, countries, and across population groups, but Africa has been identified as the most vulnerable region to climate change (Sarkodie & Strezov, 2019). Sub-Saharan Africa is home to 11% of the world's population, and the weight of the health risk associated with climate change is said to be three times greater for the entire population (Opoku et al., 2021).

11.3 Diseases and Population Health Under Climate Change

11.3.1 Disease Prevalence

Studies have identified linkages between climate change and infectious diseases. A number of biological and physical mechanisms have been proposed to demonstrate potential mechanisms by which climate change is likely to increase transmission of water- and food-borne illnesses (Bhandari et al., 2020; Levy et al., 2016). Temperature increases have sizable implications for the transmission of vector-borne diseases, and warming may also alter the distribution, breeding, and survival of the snail species implicated in schistosomiasis, whose choice of habitat is highly sensitive to water temperature (Chersich et al., 2018). Extreme weather conditions hasten the spread of pests and diseases, and high temperatures increase the spread of illnesses such as meningitis, measles, and chicken pox, to name a few. Extreme weather may also compound mental health stressor that already affects many individuals. Immune-compromised populations may be more vulnerable to increased pathogen loads associated with higher temperatures if factors such as stigma and poor health have already weakened their resilience. Climate change influences migration, which raises the risk of HIV infection (Vearey, 2018).

Heavy rains can generate stagnant water, which in turn promotes mosquitoes that spread malaria to nearby residents. Despite being difficult to pinpoint, the indirect consequences could include increased psychological stress and sadness, disease-carrying vectors, and a sense of isolation among those who have been displaced by natural catastrophes. It is now well known that malaria populations are rising in the urbanizing tropical world, particularly in unhygienic outlying areas of towns where there are insufficient facilities for disposing of community waste and where water-containing wastes make excellent Anopheles breeding grounds (Abdulkadir et al., 2017). In Nigeria, Adewoyin and Adeboyejo (2017) established that changes in climatic and socioeconomic conditions greatly influence the prevalence of malaria.

Cerebral-spinal meningitis, cardiovascular respiratory disorders in the elderly, skin cancer, high blood pressure, malaria, cholera, and child and maternal health issues are some of the direct consequences of climate change in Nigeria (Monday & Monday, 2019; Omoruyi & Kunle, 2012).

In Kenya, many people have suffered from hunger, gastroenteritis, trauma, and mental health issues as a result of the effects of drought, which include food shortages, water shortages, poor water quality, conflicts with wild animals, and mass migration (Sheriff & Mash, 2022). The drought is consequent on rising temperatures. Health experts in Kenya have stated that Kenya is witnessing a spike in both infectious and non-communicable diseases as the climate crisis escalates in the country (Xinhua, 2021). According to Anthony Wainaina, deputy director of public health in the Ministry of Health in Kenya, rising temperatures have resulted in an increase in cholera, typhoid, dengue fever, malaria, and dengue fever cases. The most pressing risks to human health identified as a result of climate change in Kenya include an increase in vector-borne and waterborne diseases and nutrition implications of food shortages due to longer drier spells (IFRC, 2021).

Highland Malaria, which was formerly rare in Kenya, has become more severe over the past two decades as a result of climate change (Wandiga et al., 2010). In Kenya where there is constant interaction between humans and livestock, there is a higher risk for the transmission of zoonotic diseases like the Rift valley fever. During the El Niño-Southern Oscillation phenomenon, there is an association between outbreak of the Rift valley fever and above-average rainfall that occurs at the warm phase of the phenomenon (IFRC, 2021; WHO, 2021). Since 2007, there have been more cholera outbreaks in Kenya, and they are strongly tied to floods caused by El Nio (Stoltzfus et al., 2014).

In Southern Africa, those at the extremes of age are most vulnerable due to their reduced thermoregulatory capacity, as well as less mobility and resources to acclimate to severe temperatures. Total mortality increased by 1% for every 1 °C increase in temperature and by 2% in people over 65, according to a study that combined data from Cape Town, Durban, and Johannesburg (Watts et al., 2018). The temperature increase and high precipitation favor vector-borne illnesses like malaria because of the vector *Anopheles arabiensis*. With Rift Valley Fever, which primarily affects the semi-desert Karoo biomes during severe La Nina years being noticed in South Africa's central grassland areas during El Nino events, the effects of climate variability are especially evident (Chersich et al., 2018; Watts et al., 2018). The effects of climate change and variability on health are continuously increasing. In South Africa, research has focused on climatically vulnerable health outcomes such as diarrhea, respiratory and cardiovascular health, and vector-borne infectious diseases such as malaria (Myers et al., 2011; Padarath & English, 2011; Ziervogel et al., 2014).

Rainfall pattern, temperature variability, humidity, land and sea surface temperature, and total precipitation were all studied in relation to malaria in Africa (Adu-Prah & Tetteh, 2015; Opoku et al., 2021; Weli & Efe, 2015). Precipitation and temperature increases the number of diarrheal cases, which leads to increased mortality rate in South Africa, Ghana, and Ethiopia (Abu & Codjoe, 2018; Azage et al., 2017; Musengimana et al., 2016; Opoku et al., 2021). Other climate-sensitive water-borne diseases with severe health consequences that have been reported in many parts of the continent include the Buruli ulcer and schistosomiasis, both of which occur in Ghana (Opoku et al., 2021; Tschakert et al., 2016). According to the World Health Organization (WHO), around 250,000 additional deaths are projected to occur annually between the years 2030 and 2050 due to malnutrition, malaria, diarrhea, and heat stress occasioned by climate change (WHO, 2015).

11.3.2 Climate Change and Population Groups

The effects of climate change on health affect all individuals across all population groups. According to Hathaway and Maibach (2018), vulnerable populations at greater risk are young children, pregnant women, older adults, people with chronic illnesses and disabilities, and people with fewer resources. The aged cohorts are particularly more susceptible to ill-health owing to the effect of their age on their physiological and immunological compositions (Adeboyejo & Adewoyin**,** 2017). Their lifestyles, nutritional status, and conditions to which they are exposed in their social and physical environments matter for their health. Conditions in the physical environment, particularly those related to climatic elements, have the propensity to aggravate health challenges among this cohort through their exposure to weather extremities and fluctuations in temperature and rainfall. Hot temperatures have been found to affect older adult's health, particularly mental, cardiovascular, and respiratory health (CDC, 2015; WHO, 2015).

In the absence of adequate planning and good governance, Bartlett (2008) opines that poor urban areas can be some of the world's most life-threatening environments with impacts on children of different ages. According to findings from her work, the increased risk of storms, flooding, landslides, heat waves, drought, and water supply constraints put the health of urban children at risk. UNICEF (2016) reported that the 2015–2016 El Niño weather phenomena, which were the worst in 50 years at the time, caused intense drought in Southern Africa. Out of 15.6 million people left in need, 8.5 million of them were children. The drought compounded existing vulnerabilities, resulting in severe food shortages, particularly in Eswatini, Lesotho, Madagascar, Malawi, Mozambique, and Zimbabwe. In 2015, UNICEF recorded that nearly 160 million children were living in areas of high or extremely high drought severity, flooding, water and heat stress, and air pollution most of whom live in Africa and Asia. Climate change threatens children's survival, development, nutrition, education, and access to health care as they begin to contend with the immediate and life-threatening dangers of climate-related disasters, food insecurity, rising air pollution, increased risk of vector-borne diseases, acute respiratory infections, diarrheal diseases, and malnutrition.

Air pollution is detrimental to children's organ and neurological development. And wildfires are far from the only source of poor air quality (Etzel, 2015). More than 93% of children across the globe live in environments where air pollution levels exceed guidelines set by the World Health Organization (WHO), according to

2018 WHO report. This can cause or exacerbate a range of health problems, from premature birth and neurodevelopmental damage to asthma and cardiovascular disease. More than 90% of children under 15 regularly breathe air so polluted which puts their health and development at serious risk, while vector-borne diseases and water scarcity—scourges exacerbated by global warming—affect more than one in four children and more than one in three, respectively (Perera & Nadeau, 2022). They suggest that early exposure to dirty air alters genes in a way that could lead to serious ailments in adulthood, changes the immune system over time, and affects learning.

Almost 11 million children die each year, of which 70% are attributable to the following six causes: diarrhea, malaria, neonatal infection, pneumonia, preterm delivery, and lack of oxygen at birth (Ruppel-Schlichting et al., 2013), all of which are linked to climate change. Merwe et al. (2022) note that increasing temperatures and decreasing precipitation led to a higher probability of malnutrition among children in a Nigerian study. In a study by Adeboyejo et al. (2020), temperature and rainfall affected the health of 72.2% of hospitalized children below the age of five in Southwest Nigeria. The children were diagnosed with five most prevalent climate-related diseases: malaria, diarrhea, meningitis, measles, and asthma (4%). They also found that female children were more affected.

Women and children will bear a heavier burden of overall health because they will be more susceptible to malnutrition, have more difficulty accessing water and wood resources, and be less able to adapt to and lessen the effects of climate change on various health aspects (Dhimal et al., 2021). Women are more vulnerable to the effects of climate change than men, primarily because they constitute the majority of the world's population and are more dependent for their livelihood on natural resources that are threatened by climate change. Furthermore, they face social, economic, and political barriers that limit their coping capacity. Women in rural areas in developing countries are especially more vulnerable when they are highly dependent on local natural resources for their livelihood. Those charged with the responsibility to secure water, food, and fuel for cooking and heating face the greatest challenges. Limited mobility places women in rural areas in a position where they are disproportionately affected by climate change coupled with unequal access to resources and to decision-making processes.

Climate migration consequent on flooding, wild forest fires, contestations for farmlands and other climate-driven disasters, and conflicts also have health consequences for the women involved. In 2017, 68.5 million people were forcibly displaced from their homes. Of these, an estimated 24 million were forced to move by flooding, forest fires, droughts, and intensified storms associated with climate change (McDonnel, 2018). Latin America, Sub-Saharan Africa, and Southeast Asia are all estimated to generate 143 million more climate migrants by 2050 (Rigaud et al., 2018). Majority of those displaced were women. In Kenya, with one of Africa's largest refugee populations, the climate crisis has the potential to both exacerbate current health risks and create new ones (IFRC, 2021). The poor displaced women are disproportionately at danger of the effects of climate change because they have less access to information, technology, and financial resources.

11.3.3 Climate Change and Sexual and Reproductive Health (SRH)

A changing climate puts sexual and reproductive health and rights in jeopardy. It is commonly known that girls and women's overall health, social, and economic well-being are disproportionately impacted by climate change. According to research, women and children had an increased risk of passing away following a disaster, including extreme weather events like hurricanes, wildfires, and flooding, by up to 14 times compared to men (Zeid et al., 2015). In some instances of climate-related calamities, more men than women may be affected. Gender norms that encourage risk-taking may make men more vulnerable. However, substantial evidence connects climate change to poor results for maternal health, a rise in the prevalence of gender-based violence (GBV), and generally limited access to SRH services, all of which have an adverse effect on family planning, abortion, and sexually transmitted infection outcomes.

Early marriage, gender-based violence, and maternal health dehydration during pregnancy can be particularly harmful to both mother and fetus since it can stunt fetal growth, release hormones that trigger labor, result in preterm deliveries, and raise the risk of anemia and eclampsia in the mother (Sorensen et al., 2018). Increasing temperatures, occurrences of heat waves and droughts, and erratic rainfall patterns can have an impact on food and water security and make it more difficult for women to acquire clean, dependable drinking water. Similarly, macro- and micronutrient deficiencies caused by food insecurity and undernutrition among pregnant women can affect pregnancy, nursing, and newborn outcomes and lead to low-weight births, miscarriages, and perinatal mortality (Sorensen et al., 2018).

Given that temperature and precipitation rates have an impact on the survival and spread of vector-borne diseases, climate change is also linked to an increase in their prevalence (Watts et al., 2018; Leal et al., 2022). Significant evidence shows that vector-borne diseases can increase the risk of spontaneous abortion, premature delivery, stillbirth, low-weight births, eclampsia, and cesarean delivery for pregnant women (Uneke, 2007). For instance, anemia, which raises the risk of postpartum hemorrhage and birth difficulties, might be made worse by malaria (Campbell-Lendrum et al., 2015). Pregnant women are predisposed to mosquito-borne infections such as the Zika virus, dengue fever, and malaria. This is due in part to their proximity to standing water as they spend time at home performing domestic duties such as cooking and those connected to water, sanitation, and hygiene (Sorensen et al., 2018). Furthermore, some evidence suggests that pregnant women may be especially vulnerable to the negative health impacts of wildfires and poor air quality. Air pollution has been linked to poor birth outcomes and respiratory disorders in pregnant women (Bekkar et al., 2020).

There is a lot of research showing how GBV, such as sexual assault, transactional sex, and sex trafficking, can be connected to increased susceptibility to climate change and specifically climate-related disasters. These are then associated with a higher risk of STIs and unwanted pregnancies. Girls and women who live in socially or physically isolated areas, as well as migrants, refugees, asylum seekers, internally displaced people, LGBTQIA+ people, girls, and women with disabilities, and girls and women who live in poverty are all more vulnerable to GBV, including sexual violence (Zeid et al., 2015). Similarly, a substantial body of research shows that in humanitarian and emergency circumstances, women and children are more likely to experience GBV and face extra barriers to getting SRH rights assistance (Onyango & Heidari, 2017).

According to research, when natural resources become limited due to climate change, girls and women travel longer distances to find food and water, increasing their risk of sexual abuse, physical abuse, and damage (Mian & Namasivayam, 2017). There was an increase in domestic violence against women and children in Australia following the 2009 bushfires. Violence that already presents in the home is been found to be made worse by pressures connected to the bushfires, such as financial instability and possession loss (Parkinson & Zara, 2013). It is projected that 1.5 million girls in Malawi are at risk of becoming child brides as a result of the effects of extreme weather events caused by climate change, which make it more difficult for families to feed and house their own children. In Uganda, rates of domestic violence, sexual abuse, and female genital mutilation (FGM) increased during periods of drought from 2014 to 2018 (Masson et al., 2019). In Uganda, rates of domestic violence, sexual abuse, and female genital mutilation (FGM) increased during periods of drought from 2014 to 2018 (Masson et al., 2019).

Further, in low- and middle-income countries and crisis-affected countries, child marriage and forced marriage are seen to increase during economic difficulties associated with climate-related shocks and stresses (Bremner et al., 2015). Early pregnancy and marriage can have detrimental effects on SRH. Pregnant girls are more likely to experience placental tears, labor obstruction, and maternal death before the age of 15 (Bremner et al., 2015). In low- and middle-income countries, a study shows that young girls may be pulled out of school and into marriage to alleviate financial hardship caused by extreme weather events (Scott et al., n.d.) In Myanmar, dropout rates were 34.7% for boys and 42.3% for girls after Cyclone Nargis in 2008 (Masson et al., 2019).

11.4 Conclusion

A healthy population is an indispensable factor that facilitates the transitions needed to achieve the sustainable development goals of the United Nations and Agenda 2063 of the African Union. Measures to protect human health are critical to reducing poverty and inequality at all scales. Health risks from climate change will significantly affect the vulnerability of individuals, communities, and health systems. Although the effects of climate change may vary from country to country based on geography and other socioenvironmental and economic factors, the health effects reported in this chapter could be valuable in planning mitigations and building resilience against the effects of climate on population health on the continent.

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Chapter 12
Spatial Distribution and Pattern Analysis of Women Sexual Violence in Tanzania

Justine N. Mbukwa, Tukae Mbegalo, and Francis Levira

12.1 Introduction

Sexual violence is a major human rights violation as well as a widespread public health concern. It takes many forms, including spousal, intimate partner violence; sexual violence by persons other than a spouse or partner, including other family members, friends, acquaintances or strangers (i.e. non-partner sexual violence); femicide, including murders in the name of "honour"; and trafficking of women (World Health Organization, 2021). Increasingly, violence by a husband or male intimate partner (or other male family member) is the most prevalent form of violence against women globally (Vyas et al., 2015). Globally, 27% of ever-married/partnered women aged 15–49 years have experienced lifetime abuse from an intimate (Waltermaurer, 2012). Approximately, one-third (30%) of all women who have been in love have faced a physical and/or sexual violence by their close lover globally. Sexual violence has significant short-, medium- and long-term effects on the physical and mental health and well-being of women, children and families (Jina & Thomas, 2013).

In the literature on intimate partner violence, evidence suggests that three to 13% of pregnant women who have experienced violence against their partners had major physical and emotional damages as well as their newborns (Campbell, 2002). Studies in the United States of America (USA) and Canada noted that physical

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mishandling of women by a friendly partner through beating constitutes 11–30% of physical damages experienced by women including damages on their head, breasts and abdomen, etc. (Campbell, 2002; Dichter et al., 2014). Violence against women also has serious social and economic consequences for countries and societies. It is one of the coercion underpinning mortalities against women leading to reduction of women labour force. It is estimated that 38% of murders of women are committed by intimate partners across the world (WHO & HRP, 2019).

Spatially, the prevalence estimate of women aged 15–49 who have experienced intimate partner violence and/or non-partner sexual violence during their lives across the WHO regions is almost similar to the global prevalence estimate standing at rate of 31% (World Health Organization, 2021). Nonetheless, according to the recent WHO, 2021 estimates, the African region has a 36% high prevalence rate as compared to the rest of the regions. The spatial estimates in terms of sub-regions indicated some heterogeneity, whereas South-Asia has a 35% IPV estimate leading by margin against Sub-Saharan Africa (World Health Organization, 2021). Tanzania like any Sub-Saharan Africa country is experiencing high incidences of sexual abuse against women above the global estimate. Approximately, 44% of married women in Tanzania have ever encountered physical/sexual violence from their intimate partner in their life span (Mccleary-Sills et al., 2013). Kazaura et al. (2016) indicated this to be about 65%.

In addition, women have experienced a wide range of sexual abuse, including rape by a stranger, threat or use of a weapon, forced anal sex and severe physical abuse by a husband or partner (Mccleary-Sills et al., 2013). Intimate partner violence has been reported to cause major threat for the mother's offspring. It has been associated with induced abortion and pregnancy loss among women in Tanzania. Stöckl et al. (2012) reported that 41% and 56% ever partnered and ever pregnant women in Dar es Salaam and Mbeya, respectively, had experienced lifetime physical and/or sexual intimate partner violence. Among this cohort, 23% experienced involuntary pregnancy loss, while seven percent experienced induced abortion. Also, physical and/or sexual violence among partners in Tanzania are associated with adverse child nutritional and future outcomes (Neamah et al., 2018). It is also associated with HIV risk behaviour among young men and their partners in Dar es salaam, Tanzania (Maman et al., 2009).

Studies on gender-based violence are widely documented (Oladepo et al., 2011; Sen & Bolsoy, 2017; Tantu et al., 2020; Kazaura et al., 2016; Nyato et al., 2019; Boy & Kulczycki, 2008). Most of these studies used desk review, descriptive statistics, bivariate analysis and logistic regression to ascertain the factors associated with sexual violence. However, little is known about the comparisons of the estimates among clusters of regions having similar sexual violence incidences to elucidate explicitly the location-specific causes of the high prevalence. Mcilwaine (2013) noted the existence of variation of violence according to geographical areas as well as other underlying factors and related processes in cities of the global South. It also noted that the fundamental causes of gender-based violence embedded in patriarchal relations are ubiquitous across place and that certain "triggers" or "risks" can lead to variations between urban and rural areas. Empirical evidence also documents that some factors associated with high risk of partner violence operate differently between countries and also within countries. It is against this background that this study investigates the spatial dimension of sexual violence across regions in Tanzania.

12.2 Data and Methods

The study was conducted in Tanzania among women aged 15–49 years. We used the secondary data from the latest Tanzanian demographic and health survey (DHS 2015/16). Normally, the survey is conducted every five years. The women recode dataset was accessed via World Bank database one http://www.dhsprogram.com). A representative random sample of 10,333 women was used as a base for analysis. The study adopted the cross-sectional research design. The detailed clarification on the sampling design and techniques is well explained (Musheiguza et al., 2021).

Outcome Study Variables Sexual violence, measured by the question on whether a woman was beaten by her partner if she refused to have sex in the DHS, was used as the outcome variable of this study. This was coded as Yes = 1 or No = 0.

Explanatory Factors We use the variables that have been documented, in existing literature, to be associated with women's sexual violence. These are age, marital status, education, education level of husband/partner, wealth index, occupation, cohabitation and alcohol use (Table 12.1).

Data Analysis Data analysis was done using both ArcMap software version 10.8 and STATA version 15. The outcome of interest (sexual violence) by region was presented using the frequency table before being spatially distributed to the ArcMap GIS for all regions. Each predictor, in relation, to the response variable was tested using Chi-square. Level of statistical significance was set at $P < 0.05$.

Table 12.1 Measurement of the variables

S/N	Explanatory variables	Measurement	Coding
1	Age of the respondent	Nominal	1 = 15–19; 2 = 20–24;3 = 25–29; 4 = 30–34; 5 = 35–39; 6 = 40–44; 7 = 45–49
2	Education level of a husband	Ordinal	1 = no education; 2 = primary; 3 = secondary; 4 = higher
4	Wealth index	Ordinal	1 = poorest; 2 = poorer; 3 = middle; 4 = richer; 5 = richest
5	Occupation	Nominal	1 = working; 0 = not working
6	Cohabitation	Scale	1 = less than 18; 2 = 18–24; 25–31; 3 = more than 31
7	Alcohol use	Nominal	1 = yes, 0 = no
8	Marital status	Nominal	1 = never in union; 2. Married; 3. Living with a partner; 4. Widow; 5. Divorced

12.3 Results and Discussion

As shown in Fig. 12.1, the prevalence of sexual violence was unevenly distributed across all regions in Tanzania. The results show three clusters, ranging from highest (4.1–8.4) to lowest prevalence rate (0–2). The first cluster constitutes the regions with the highest prevalence rates. The regions include Mara, Katavi, Tabora, Kigoma, Singida, Shinyanga, Simiyu, Rukwa and Geita. While Mara, Geita, Simiyu and Shinyanga are regions around Lake Victoria, Kigoma, Rukwa and Katavi regions are around the Lake Tanganyika. The remaining high prevalence regions, Singida and Tabora, are in the central part of Tanzania. The second cluster comprised of the regions whose sexual violence rate ranged from 2.1 to less than 4.1. These regions include Manyara, Dodoma, Kagera and Arusha, whereas the least

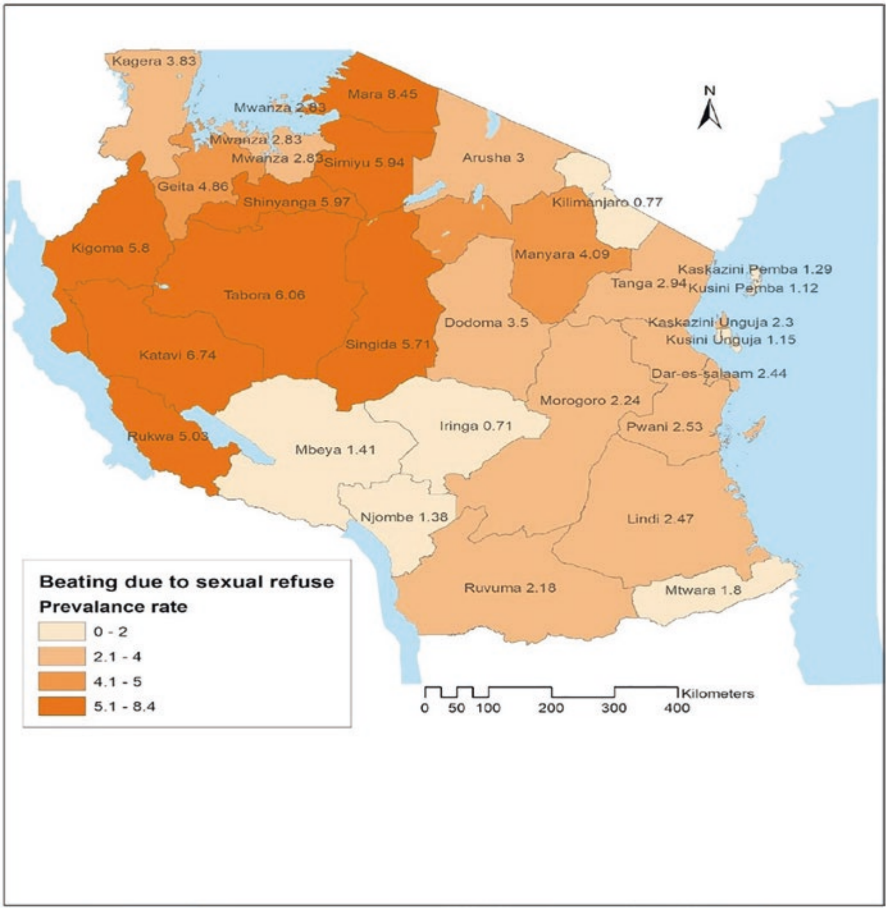

Fig. 12.1 Spatial distribution of sexual violence in Tanzania

prevalence rates ranging from zero to two were noted in Mbeya, Iringa, Mtwara, Kaskazini Pemba, Kusini Unguja and Kusini Pemba.

In Table 12.2, we present the cross-tabulation for the socio-economic and demographic variables associated with sexual violence in the regions where the prevalence rates were highest (cluster one). We compare the degree of association of each predictor with sexual violence across the high-prevalent regions. Age of the respondents was found to be positively correlated with sexual violence in Shinyanaga, Geita and Rukwa. In terms of partner's education, the study findings reveal a positive association with women sexual violence mainly in Mara, Katavi and Geita regions. Mara had the highest prevalence of sexual violence compared to other geographical regions in Tanzania. Wealth index, occupation, cohabitation, marital status and alcohol intake were all positively associated with the prevalence of sexual violence.

However, while wealth index was statistically significant ($P < 0.05$) in all the regions, age was only statistically significant in its association with sexual violence in Shinyanga, Rukwa and Geita. Partner's education was significant in Mara, Katavi and Geita, while occupation was significant in Tabora, Kigoma, Singida, Rukwa and Geita. Years of cohabitation, alcohol drinking and marital status also had varying level of significance across the regions as shown in Table 12.2.

On the other end of the divide, among regions with the lowest prevalence rates, and as shown in Table 12.3, findings show that the association between the predictor variables and sexual violence was also not uniform. No single explanatory variable was statistically significant across all the regions as witnessed with wealth index in the first cluster. In Mbeya, partner's education, wealth index, occupation and alcohol intake were significant, while age, occupation, cohabitation and alcohol were significant in Iringa. Partner's education, occupation and marital status were significant in Kusini Unguja; age and partner's education in Kusini Pemba; and age and cohabitation in Kaskazini Pemba. None of the variables was statistically significant in Mtwara. Kusini Unguja, in Zanzibar, is a predominantly Islamic region with strict marital regulations according to Islamic tenets. Hence, that marital status was a significant predictor of sexual violence in the region, and not in any other region, was not surprising.

With respect to age, the results in this study are consistent with a study conducted in Nigeria (Benebo et al., 2018). The study commended that as the age of the woman increases, the likelihood of violence also tends to increase if a couple lives together for a long period of time. These results suggest that in those regions/clusters, it is very likely that women and men have been in union for a long period of time. Similarly, on the association between partner's education and sexual violence, our findings mirror those of Seid et al. (2021) who found that women whose partner's education is primary and secondary schools experience low sexual violence compared to those having no education. The association between education, wealth index, year of cohabitation, alcohol intake and marital status is equally in line with findings in other studies (Kiss et al., 2012; Kusanthan et al., 2016; Habyarimana et al., 2021; Semahegn & Mengistie, 2015; Adu et al., 2022; Greene et al., 2017; Owusu Adjah & Agbemafle, 2016; Antai, 2011; Deribe et al., 2012).

Table 12.2 Cross tabulation of cluster one regions by predictor variables

Predictor variables	Sexual violence								
	Mara	Katavi	Tabora	Kigoma	Singida	Shinyanga	Simiyu	Rukwa	Geita
	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)
Age of the respondent	7.49 (0.278)	2.33 (0.887)	3.33 (0.767)	4.45 (0.614)	6.83 (0.337)	23.16 (0.001)	5.55 (0.475)	16.71 (0.010)	16.71 (0.010)
Education level of a husband	15.89 (0.001)	12.69 (0.005)	4.18 (0.243)	4.21 (0.239)	2.65 (0.450)	2.69 (0.441)	5.28 (0.1530	5.65 (0.227)	27.04 (0.000)
Wealth index	21.25 (0.000)	15.10 (0.004)	22.52 (0.000)	18.16 (0.001)	13.458 (0.009)	10.59 (0.031)	10.12 (0.039)	12.19 (0.016)	12.19 (0.016)
Occupation	13.51 (0.095)	10.78 (0.095)	21.13 (0.007)	33.59 (0.000)	21.61 (0.003)	9.71 (0.206)	13.86 (0.054)	27.04 (0.000)	27.04 (0.000)
Years at first cohabitation	8.89 (0.261)	20.56 (0.004)	22.88 (0.002)	9.19 (0.239)	15.68 (0.028)	14.77 (0.039)	21.73 (0.003)	17.76 (0.013)	17.76 (0.013)
Drinking alcohol	2.05 (0.152)	0.87 (0.351)	3.74 (0.053)	0.01 (0.955)	0.10 (0.754)	10.59 (0.001)	7.56 (0.006)	27.97 (0.000)	27.97 (0.000)
Marital status	4.91 (0.427)	48.09 (0.000)	16.954 (0.005)	13.98 (0.016)	16.37 (0.006)	7.75 (0.170)	9.79 (0.081)	8.07 (0.153)	8.07 (0.153)

Source: TDHS (2015/2016)
p-values in parenthesis

Table 12.3 Cross tabulation of cluster three regions by predictor variables

	Sexual violence					
	Mbeya	Iringa	Mtwara	Kusini Unguja	Kusini Pemba	Kaskazini Pemba
Predictor variables	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)
Age of the respondent	4.21 (0.648)	18.79 **(0.005)**	2.73 (0.842)	7.99 (0.239)	12.35 (0.055)	17.44 **(0.008)**
Education level of a husband	10.66 **(0.014)**	5.89 (0.117)	1.51 (0.681)	48.22 **(0.000)**	16.12 **(0.001)**	6.65 (0.156)
Wealth index	21.04 **(0.000)**	7.28 (0.122)	7.33 (0.119)	1.10 (0.594)	4.27 (0.371)	3.38 (0.496)
Occupation	15.24 **(0.033)**	19.06 **(0.015)**	5.92 (0.550)	24.45 **(0.001)**	6.82 (0.447)	13.76 (0.088)
Years at first cohabitation	4.78 (0.687)	24.27 **(0.000)**	3.31 (0.769)	9.86 (0.131)	9.10 (0.168)	22.38 **(0.002)**
Drinking alcohol	4.11 **(0.043)**	13.78 **(0.000)**	0.67 (0.414)	0.968 (0.325)	–	–
Marital status	8.07 (0.152)	8.39 (0.136)	7.11 (0.213)	12.27 **(0.031)**	0.9943 (0.608)	3.46 (0.325)

Source: TDHS (2015/16)
p-values in parenthesis

12.4 Conclusion

In this chapter, a national representative Tanzania Demographic Health Survey data (TDHS, 2015/16) was used for the analysis of women sexual violence. The study finds that majority of the regions in the country had high prevalence of sexual violence, with Mara region topping the list. The regions with the highest prevalence were clustered around Lakes Victoria and Tanganyika and in the central part of Tanzania. Regions with low prevalence rates included Kusini Unguja and Kusini Pemba regions. As wealth index was found to be statistically significant in its association with women sexual violence in the study area, efforts to scale-up women empowerment and ownership of assets for creating wealth should be intensified in Tanzania.

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Chapter 13
Associating Poverty with Gender-Based Violence (GBV) Against Rural and Poor Urban Women (RPUW) in Cameroon

Loveline Kongla Nsahlai, Kouankem Constantine, and Petnga Nyamen Simon Pierre

13.1 Introduction

Gender is a theoretical and methodological approach to the cultural construction of sexual differences that alludes to inequalities between the female and male sexes that a particular society has determined and assigned (Uwameiye et al., 2013); and to the way, the two aspects relate to each other (Chile, 2004). Power imbalances are created (Learning Network, 2021) that go beyond geography, race, culture, class, and religion, touching virtually every community in every corner of the globe (The Presidency Ministry of Devolution and Planning, 2014). Violence against women is regarded as, "Any act of GBV that results in physical, sexual or psychological harm or suffering of women, including threats of such acts, coercion or arbitrary deprivations of liberty, whether occurring in public or private life" (OXFAM, 2007). Gender-based violence against women (GBVAW) is a term that broadly incorporates many behaviors that manifest as physical, sexual, or psychological damage to women or girls. According to World Bank (2019), GBVAW is a global pandemic that affects one in three women in their lifetime.

Violence against women is more than a health issue (Heise et al., 1994) affecting all socio-economic and cultural groups throughout the world at a high cost to the individual and society. It results in human health problems including, but not limited to fatal outcomes, acute and chronic physical injuries and disabilities, serious mental health problems, and behavioral deviations increasing the risk of subsequent victimization and gynecological disorders, unwanted pregnancies, obstetric complications, and STDs (FAO, 2009). The significance of women's health and

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socioeconomic well-being is increasingly recognized and seen as a necessity for sustainable development and an essential contributor to the economic growth of every society (Krantz, 2002). In the last decades, the issue of violence against women has moved from the shadows to the foreground of commitments to attain sustainable development. Sustainable Development Goal 3 aims to prevent needless suffering from preventable diseases and premature death by focusing on key targets that boost the health of a country's overall population. This gives a "raison d'étre" for this study. However, GBV remains a global health and human right issue that cuts across regional, social, and cultural boundaries (Okemgbo et al., 2002; Mcilwaine, 2013; Majoo, 2011; Irish Consortium on GBV, 2018), regardless of culture, socioeconomic class, or religion (USAID, IGWG & PRB, 2010) often considered a "tip of the iceberg or silent epidemic" (Muluneh et al., 2020).

Nevertheless, its contours are shaped by economic, political, and sociocultural contexts (Johnson, 2011). Across sub-Sahara Africa, reports of the prevalence and incidence of GBV have been reported (Roman & Frantz, 2013). It involves men and women with women usually, but not always, being the victim (OXFAM, 2007; USAID, 2008; Kabeta, 2010) derived from unequal power relationships between men and women (WHO, 2013) for diverse reasons, and affects them disproportionately (UNIFEM, 2005; USAID, 2010; Malgesini et al., 2019). According to FAO (2018), it is an umbrella term covering a wide range of abusive, exploitative, and often sexualized actions that are perpetrated against a person's will (Uwameiye et al., 2013).

Poverty undeniably intertwines with GBV; Poverty is by itself a form of structural violence that affects health, one embedded in social structures marked by inequalities (Malgesini et al.; 2019). Absolute poverty refers to the lack of basic human needs, which includes water, nutrition, health care, education, clothing, and shelter (Olufunmilayo et al., 2013). It is in line with this definition that poverty is used in this study. The major causes of women's poverty are embodied in unequal power relations between women and men, discriminatory inheritance rights, lack of access to property, and productive resources (UNIFEM, 2005). In Cameroon, while 39% of the national population lives below the poverty line, this rate rises to 51.5% for women; 79.2% of them are underemployed. Women have access to plots that they cultivate and this does not allow them to have control over it and enjoy inheritance rights from their parents and husbands (Brun, 2019).

GBV against RPUW in Cameroon is a silent "disease" that is slowly but surely affecting and killing women psychologically and physically. This is caused by poverty/financial insecurity, language barrier/illiteracy, and other societal/cultural norms that draw them "behind the curtain." However, GBV against them continues to persist unnoticed in such a way that the women and society as a whole become more and more prone to poverty and health challenges, whereas health is an important determinant of economic development; a healthy population means higher productivity.

The main objective of this study is to identify and assess the causes and health issues of GBV against RPUW in Cameroon. The hypotheses that guided this study are (1) GBV against RPUW in Cameroon is significantly influenced by location and (2) GBV health outcomes against RPUW retard economic growth in Cameroon.

13.2 Literature Review

GBV is not only hugely diverse in nature, but it also has a very high incidence throughout the global South. While there are variations between urban and rural areas, discussions suggest it tends to differ in nature rather than in incidence (Morrison et al., 2007). Although GBV cuts across cultures, societies, and economic lines and affects women in developed and developing countries alike, women living in poverty are more vulnerable (Women Thrive, 2009), particularly poor women from less developed countries (Malgesini et al., 2019). A lot of literature is yet to be covered in the domain of associating GBV against RPUW to poverty in sub-Saharan Africa. Regardless of numerous positive attributes associated with rural environments, the presence of violence against women is indeed a serious problem (Johnson, 2011). Women are generally poorer and less educated than men and account for a greater segment of the population living in absolute poverty (UNIFEM, 2005). GBV takes place in ways that are both unique and disproportionately high in rural and remote communities (Learning Network, 2021) like urban slums. A study in the Philippines shows that living in urban slums can lead to a greater incidence of violence against women (Hindin & Adair, 2002). Poverty may influence the lives of young men and young women differently, and violence may sometimes be a survival strategy (Unterhalter, 2012).

When analyzing the rural environment in relation to the issue of violence against women, it is necessary to mention questions of unemployment and/or poverty and low living standards (Johnson, 2011). According to Kabeta (2010), GBV is a multifaceted phenomenon grounded in the interplay between personal, situational, and socio-cultural factors. A common assumption in the literature on GBVAW is that domestic violence is more widespread among the poor. A variety of domestic violence perspectives promote this idea that families living in impoverished conditions are subject to higher levels of stress than families not living in poverty and that as a result of experiencing high levels of stress, poor families are more prone to family violence (Martin et al., 1999). Even in contexts where women are able to acquire access to resources such as land, they continue to face the challenge of access to other resources for their care (Manjoo, 2011). However, women's economic and physical security is compromised and leaves them more vulnerable to violence and poor health. Arisukwu et al. (2021), in their study of the perception of domestic violence among rural women in Kuje, Nigeria, opined that though women in rural Nigeria constitute major participants in crop farming, they are denied the right to own farm lands or even the right to inherit same from their parents. Therefore, except a girl is married, she has no legal or traditional means of owning farmland for farming. Yet farming is the main economic activity in the rural areas in Nigeria.

Even where a woman has access to farmland through her husband, the husband controls the proceeds from the farm economy.

Women Thrive Publication (2009) argues that violence against women is a major cause of poverty; it keeps women from getting an education, working, and earning the income, and they need to lift their families out of poverty. Owning a property can give women greater bargaining power within households and protect them against domestic violence. GBV reduces a woman's ability to work and provide for her family. Furthermore, Chisaa et al. (2021) elucidate that a high level of poverty and socio-economic challenges in Nigeria undoubtedly contribute in no small measure to the prevalence of domestic violence. Bates et al. (2004) reiterated that women's economic contribution might increase the risk of violence by undermining male authority and establishing gender roles. This interpretation is that men's inability to provide economically for their families may place women at increased risk of maltreatment; violence against them is the ultimate weapon for men wishing to assert power, and control (Mcilwaine & Data, 2003), used to resolve a crisis of male identity caused by poverty (Malgesini et al., 2019).

Within low-income urban areas themselves, there are particular localities where GBVAW occurs more frequently (Kabeer, 1999). In 2008, Kabeer pushed his argument that social relations in urban areas are particularly fragmented especially among poor women, and this can lead to higher risks for women because when women "do not have someone to talk to,", their experience of domestic violence tends to be high in urban milieus and vice-versa. Some types of occupation also put poor urban women more at risk of GBV, as is the case of sex workers. Mcilwaine and Data (2003) suggest that violence against women by male partners is less prevalent in cities than in rural areas, though women are most likely to be vulnerable to GBV, especially in urban slums.). Greenfeld et al. (1998), Davis (1999), and Lyon (2000) advocated that poor women are more likely than others to experience violence from their partners, partly because they have fewer options, and its combination with poverty raises particularly difficult issues for them. The authors were focused on showing the vulnerability of women living in rural areas and urban slums to GBV and poverty; our study will not only focus on these same aspects in Cameroon. We shall see how geographical location influences GBV against RPUW in Cameroon.

13.3 Research Methodology

13.3.1 Methods and Instruments

The research design was cross-sectional and carried out in the 10 regions of Cameroon irrespective of religion, culture, and tradition. The study population comprises women of different ages and statuses (old, young, married, and single) residing in the study area who were of age 14 and above. A stratified sampling technique was used to divide the study area into rural and urban where we had rural women in the rural milieus and poor urban women in the urban milieus (slums). Thereafter, a simple random sampling technique was organized to administer the questionnaire to each stratum in the different regions of the study area. A sample size of 200 women was randomly chosen from the 10 regions of the study area; that is, 20 women (10 from the rural milieu and 10 from urban poor from the slums) were chosen from each region. Data was gathered via direct and indirect observations, interview guides, and questionnaires; most of the research was "remote–controlled" using research assistants. Two hundred (200) copies of the questionnaire were administered across the stratified areas. Data was analyzed using simple percentages, descriptions, and explanations.

13.3.2 Location of Study Area

Cameroon is a Central African country situated in the Gulf of Guinea covering a surface area of about 475000 km^2 with a population of about 27 million inhabitants dispersed in 10 administrative regions. The settlement is both rural and urban. Cameroon of bordered on the North by Chad, on the West by Nigeria, on the east by the Central African Republic, and on the south by Equatorial Guinea, Gabon, and Congo (Fig. 13.1).

13.4 Results and Discussions

13.4.1 Causes of GBV against RPUW in Cameroon

Many researchers have agreed that there are three broad perspectives for understanding the causes of violence against women: psychological/individual, feminist, and societal (Manjoo, 2011). Violence occurs due to a male's higher level of testosterone (hormone theory), and men have evolved to have more violent tendencies than women do (evolutionary theory). Violence against women is said to result from social inequalities, gender, and unfair distribution of income. According to Heise (1999), the causes of GBV might be embedded in a macrosystem, exosystem, and microsystem or be related to the perpetrator's personal history. The ecological approach to GBV argues that no one factor alone "causes" violence toward a woman. The causes of GBV against RPUW in Cameroon are poverty/economic dependency of women on men (financial insecurity), rigid gender roles, language barrier/illiteracy, and cultural/social norms/community tolerance (Table 13.1).

Table 13.1 shows that 98% of RPUW agreed that poverty/economic dependence of women on men contributes to GBV against them. This indicates that among all

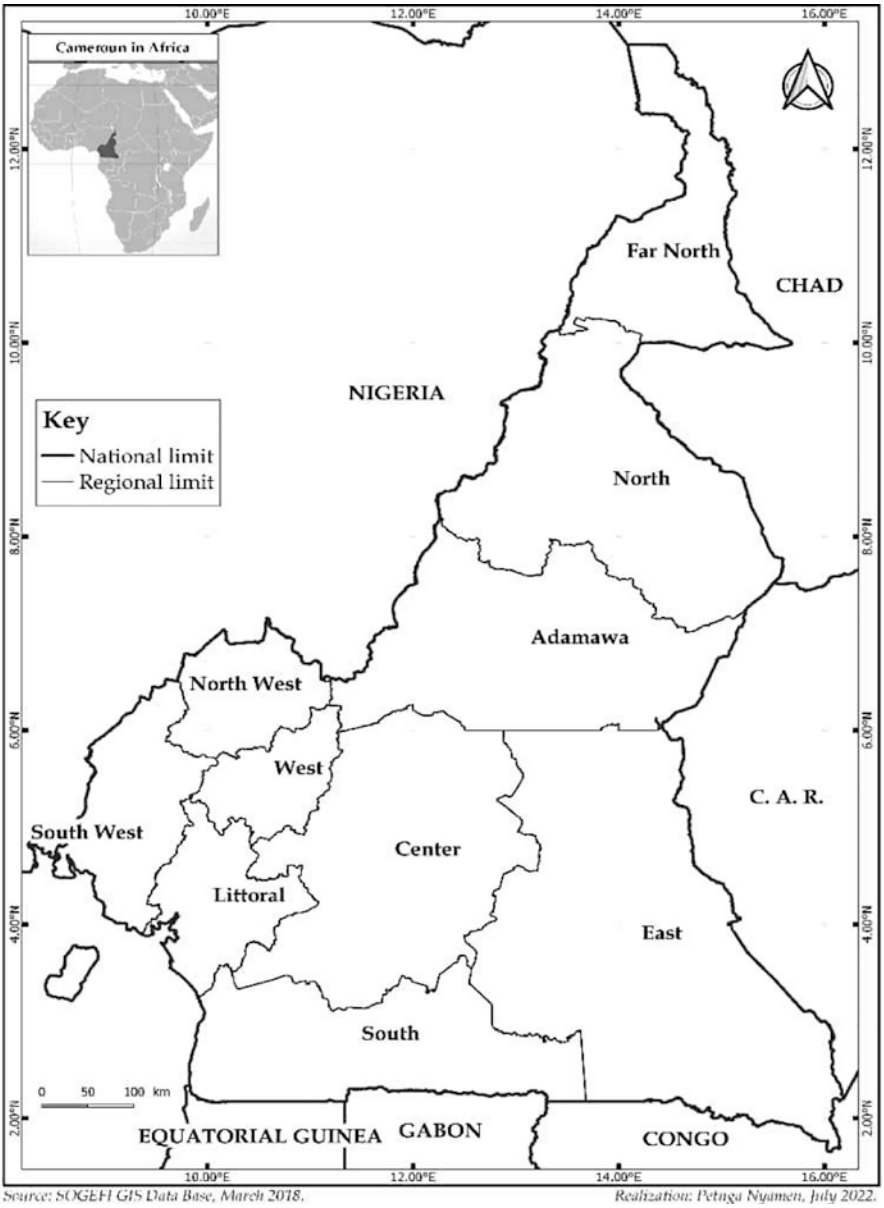

Fig. 13.1 Location of the study area. (Source: SOGEFI GIS Data Base, March 2018)

Table 13.1 Respondents' views on the causes of GBVAW in rural areas and among poor urban women in Cameroon

Surveyed localities	Respondents	Frequency of causes of GBV against RPUW			
		Rigid gender roles	Cultural/social norms/community's tolerance	Language barrier/ illiteracy	Poverty/ economic dependency
Littoral	20	10	16	16	20
Center	20	14	17	18	20
South	20	16	14	16	20
South west	20	16	9	17	20
North west	20	17	10	14	20
East	20	15	13	19	20
Adamawa	20	18	18	19	18
North	20	19	15	17	19
Far north	20	20	17	19	19
West	20	16	16	17	20
Total	200	161	145	172	196
Percentages		80.5%	72.5%	86%	98%

Source**:** Fieldwork (2022)

the causes, poverty/economic dependence of women on men strongly contributes to violence as compared to the other causes.

13.4.1.1 Poverty/Economic Dependency

Women, and some distinct groups of women, may be particularly vulnerable to violence, such as women living in poverty, widows, indigenous women, disabled women, women in detention, women in situations of armed conflict, and women living in rural or remote communities (OXFAM, 2007). Poverty is a stressor that triggers domestic violence and exacerbates existing violence. Families in poverty are more likely to suffer from domestic abuse since financial difficulty creates stressful conditions that fuel violence (Johnson, 2011). Gibbs et al. (2017), sharing same point of view as Johnson (2011), stressed on the fact that poverty is a key driver of women's experiences of Intimate Partner Violence (IPV) as it leads to increased dependency on a male provider and lower bargaining power in the household. Bates et al. (2004) and Katembo (2015) stated that women's economic dependence on men is one of the major causes of domestic violence. Poverty and lack of economic opportunities make men more likely to engage in violence and substance abuse, increasing the risk of GBV (Camey et al., 2020). In other words, total dependency on a man, by the family members, leads to frustration and he sometimes expresses it through violence (Njenga, 1999).

According to UNIFEM (2005), poor women are more vulnerable to all forms of violence because they typically live in uncertain and dangerous environments; resource use and allocation are the domain of the males in the community. Oladepo et al. (2011) ascertained that the lack of resources could facilitate stressful situations, which is a precursor to violence. GBVAW has also been associated with food insecurity, which is a proxy for poverty (Gibbs et al., 2017). This implies that household food insecurity is associated with increased IPV experience for women (Gibbs et al., 2018; Malgesini et al., 2019). In Cameroon, findings reveal that violence against RPUW mainly emanates from poverty. About 75% of respondents opined that if they had financial security, they would circumvent GBV against them. They also ascertained that all the other causes of GBVAW exist because of limitations of financial autonomy to support themselves obliging them to stay in abusive marriages to suffer violence. In this vein, it is understood that poverty is articulated in the constitution of violence for these women and they have lesser possibilities of fighting for their rights. This is contrary to what happens to women in non-poor urban areas where women are provided with greater opportunities to cope with violence more effectively (Mcilwaine, 2013). When women are more able to operate independently economically and socially, they are able to challenge violence perpetrated against them (Chant, 2007). This ascertains the fact that GBV against RPUW is caused by poverty and this is significantly influenced by their location in rural and poor urban milieus.

13.4.1.2 Rigid Gender Roles

Rigid gender roles are societal beliefs that claim that one group of people is superior to another group. These beliefs perpetuate the notion that males are superior to females (Manjoo, 2011) and pervasive discrimination against women in both the public and private spheres (FAO, 2018). In Cameroon, it was found that 80.5% of violence against RPUW was a result of rigid gender roles, which have made women believe that violence against them by their male counterparts is normal and should not be regarded as a crime. The highest identified rigid gender role was, “women caring for children while the men hunt for food by providing women with money from their jobs”; this role has placed women “behind the curtain” of financial security and has amplified women’s economic dependence and hence, GBV against them. In this same line, Arisukwa et al. (2021), in Nigeria, revealed that rural women sometimes do not perceive domestic abuse or other violent acts against them as a crime. In some cases, rural women ignorantly support and sometimes enforce abusive acts against other women and girl-child in society. Past studies in non-poor urban areas revealed that through higher welfare and education (Tranchant et al, 2017), people are emancipated and gender roles are overlooked. This confirms our stated hypothesis that; “GBV against RPUW in Cameroon is influenced by their location.”

13.4.1.3 Cultural and Social Norms/Community Tolerance

Generally, cultural and social norms identify males as aggressive, powerful, unemotional, controlling, and therefore, condoning men as dominant. Some cultures do not consider wife beating to be a form of violence. Sexual harassment of girls by male members of the community is the norm. Rape is not talked about in the community and generally goes unpunished. In some societies, the practice of "wife inheritance" (marrying a relative of the deceased husband) is forced upon a widow to protect family assets through the male inheritance line, preventing women from being able to legally inherit land and property regardless of national laws designed to protect their rights (UN Millennium Project, 2005). Prevailing strong attachment to cultural practices that are discriminatory and obnoxious toward women is inherent in rural communities; culture, religion, and family often compel women to embrace suffering/abuse as a normal way of life (Chisaa et al., 2021). Cultural and social norms in our study area range from polygamous practices, forced marriages, child marriages, patriarchy, bride price, and religion (Fig. 13.2).

Specifically, in the west, north-west, and northern regions of Cameroon, women are said to be very submissive because they were brought up to obey their husbands. This makes it difficult for them to react when they are in an abusive marriage. They do not complain because family members and the entire society will see them as bad women who are not able to keep their men. In these rural communities, informing family elders is the first step in reporting an abusive person; but unfortunately, most elders value their families' reputations over the safety of the victim. The sufferer is strongly advised to return to her household, with the recommendation, "pray for your husband, everything will be fine." In the south, center, and east regions, the social behavior of women does not prevent them from being subject to GBV, but

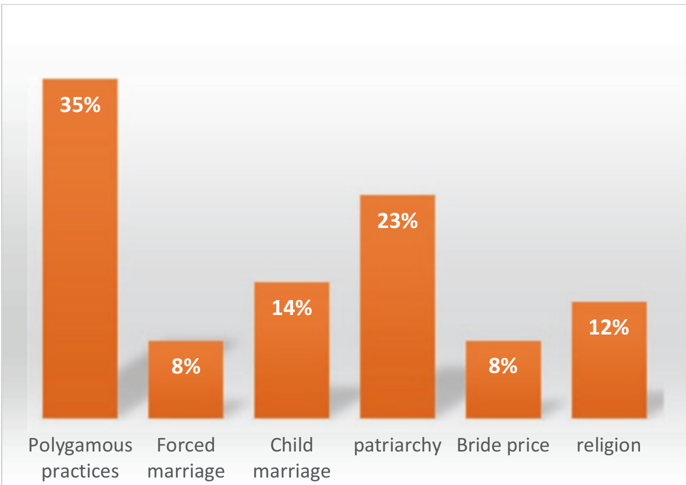

Fig. 13.2 Various cultural/social norms. (Source: Fieldwork, 2022)

they are known to be less submissive in nature. They are more prompt to react when faced with violence. The discrepancies between these women's behavior stem from the fact that in some cultures, there is a saying, directed at women that "marriage is not easy, but you stay in it regardless of what happens." However, in poor and non-poor urban areas, cultural/societal norms are a minor cause of GBV because they do not adhere to any cultural norms, and the society is mostly constituted of persons from different cultural backgrounds. This indicates that women in rural areas are more disposed to GBV when compared to women in urban areas, implying that location plays a crucial role in GBVAW.

Figure 13.2 shows that out of 72.5% of respondents who acknowledged that cultural/social norms are a cause of GBV, polygamy is the major variable (35%). This is because the cultural setting of most tribes and the Muslim religion that dominates the Adamawa, north, and far north regions of Cameroon encourage polygamous marriages. This engenders GBV against RPUW because most men in poor polygamous homes find it difficult to cope with their wives' and children's financial needs; so, the men exercise violence against their wives because they are unable to play their role as husbands. Some respondents (23%) opined that patriarchy is a second major cause of GBVAW. The UN Millennium Project (2005) maintains that despite the many international legal and human rights instruments for which most African states are signatories, customary laws based on a patriarchal system prevail and fail to provide women with their rights.

Early marriage prevents the development and preparation of girls to assume the role of wife and mother at an early stage in life, and this makes them more vulnerable than other married women (Arisukwu et al., 2021). More so, child Marriage usually means an end to a girl's education, vocation, and right to make life choices. Research confirms that girls who marry during their childhood are at greater risk for intimate partner violence (IPV) than girls of the same age who marry later (Malgesini et al., 2019). Respondents (14%) shared the view that child marriage is a cause of GBV; it was observed that among Muslim households, young girls below the age of 16 married to older men faced physical trauma due to early sexual activity that affects their health. A proportion of 8% of respondents shared the view that the payment of bride price especially to a poorer family for their daughter is like buying her; she becomes their property and most often is subjected to violence by her husband. In non-poor urban areas, early and forced marriages are not prevalent as in rural and poor urban areas because girls are from rich backgrounds, go to school and are educated, and know their rights. We see that poverty and location have an influence on GBV against RPUW in Cameroon.

13.4.1.4 Language Barrier/Illiteracy

Cameroon counts about 248 national languages; that is, Pidgin English and two official languages (French and English). RPUW especially those in rural communities are largely illiterate (limited ability to speak and understand French and English languages) as seen in Table 13.1 (86%). Among this 86%, 47% received non-formal

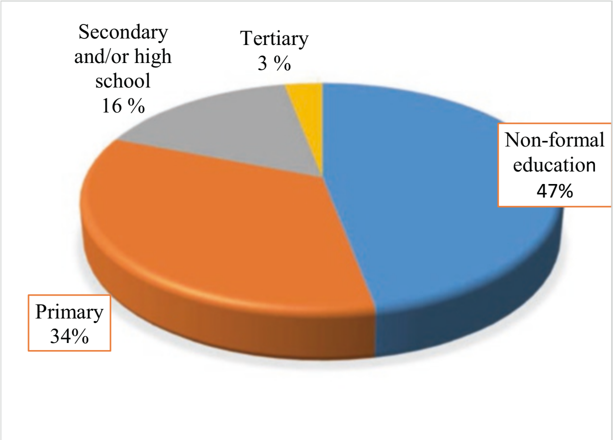

Fig. 13.3 Educational qualification of RPUW. (Source: Fieldwork, 2022)

education, 34% primary, and 16% secondary and/or high school (Fig. 13.3). Generally, messages on GBV are passed across using either French or English languages, and most women in rural milieu are not versed in these official languages. Their illiteracy is a limiting factor for them to understand GBV information from traditional media like radio, television, newspaper, and magazines rendering the information inaccessible to them (absence of the use of their mother tongue). Though NGOs and the government endeavor to solve the problem by mobilizing local media, particularly community radios, to inform the community of the legal provisions for obtaining justice regarding physical assault and GBV, the time is often inappropriate for the women because they are most often busy with their farm and household chores at given hours. It should also be noted that at times, high vocabulary is used, and this distorts the understanding of information by poor urban women who most often try to understand the official languages. According to Marketa and L'udmila (2018), insufficient education is connected to poor awareness of assistance services for women experiencing violence; most women are not aware of the existence of shelters for abused women. Unlike in urban especially non-poor urban areas, people are more educated, meaning that language barrier/illiteracy is not a determinant of GBVAW. Nevertheless, location significantly influences GBV as opined by the National Coalition Against DV (www.ncadv.org) that GBV is more prevalent in rural communities than in urban and suburban communities.

13.4.2 *Forms of GBV and GBV Health Outcomes Among RPUW in Cameroon*

Home is supposed to be a secure environment, yet in many societies in Sub-Saharan Africa, many women experience violence in diverse forms: physical, emotional/psychological, and sexual (Vadnais et al., 2006). The manifestations of all these

Table 13.2 Different forms of GBV against RPUW in Cameroon

Surveyed localities	Respondents	Frequency of forms/types of GBV against rural and poor Urban women			
		Domestic violence/ IPV			Female genital mutilation
		Emotional/ psychological violence	Physical violence	Sexual violence	
Littoral	20	17	11	6	–
Center	20	14	16	3	–
South	20	15	14	3	–
South west	20	16	7	8	3
North west	20	16	6	10	2
East	20	15	15	3	–
Adamawa	20	17	5	2	–
North	20	18	4	3	–
Far north	20	17	3	7	5
West	20	16	6	2	–
Total	200	161	87	45	10
Percentages		80.5%	43.5%	22.5%	5%

Source: Fieldwork (2022)

types of violence are underpinned by prevailing gender ideologies and identities that have long been known to vary across place and space (Mcilwaine & Data, 2003). The various forms of GBV against RPUW in Cameroon as revealed by our findings are Domestic violence ((Intimate Partner violence (IPV) and Female Genital Mutilation (FGM) (Table 13.2).

Table 13.2 shows that DV is the most prevalent form of violence experienced by RPUW due to their inability to reproach men because society condones it. Secondly, their economic/financial dependence on their husbands has made them accept and continue living in violence. It is noted that DV or IPV encompasses physical violence (PV, 43.5%), emotional/psychological violence (EPV, 80.5%)), and sexual violence (SV). FGM is limited but causes serious damage to women's health.

13.4.2.1 Domestic Violence (DV) or Intimate Partner Violence (IPV)

DV or IPV is the most prevalent form of GBV worldwide (Heise et al., 2002; Kabeta, 2010). It functions as a means of enforcing conformity with the role of a woman within customary society (Chisaa et al., 2021). It is a serious challenge in developing countries to study DV because it occurs primarily within the private sphere of the family. DV against women is a hidden global epidemic that occurs in all countries with detrimental effects on the health and well-being of women (Nmadu et al., 2022). Although both men and women can be victims, the prevalence and detrimental effects of DV, particularly sexual and physical violence, are higher among women (Johnson, 2011; Bagwell–Gray et al., 2015; Egnonwa et al., 2018). In Cameroon, 43.2% of women in union are confronted with DV; 39.8% and 14.5% face emotional and sexual violence, respectively.

13.4.2.1.1 Physical Violence (PV)

Physical violence involves pushing, shaking, throwing something at a woman, slapping her, twisting her arm or pulling her hair, punching or hitting her with something harmful, kicking, dragging, beating, choking, burning her on purpose, and threatening or attacking her with a weapon (gun, knife …) (Nmadu et al., 2022). Cameroon is not an exception; among the many cases of violence reported or observed was PV (43.5%) as seen in Table 13.2; most of the victims were poor urban women as compared to rural women because women in rural areas are generally more submissive to their counterparts. Most of the victims were those from very poor families, who got married early due to precarious living conditions in their homes hoping for a better life and those who were forced into marriage by their parents in a bid to reduce family burden. Due to these reasons and the fact that the community has sanctioned these acts, their husbands who have moved with them to poor urban areas far away from their homes regard them as inferior people who have nowhere to run to and whom they have to exercise their superiority on them through PV.

It was observed that PV is higher in the Littoral and Center regions that harbor bigger cities with many urban slums where the poor reside; as for the high prevalence in the east and south regions, it is accounted for by the fact that they have a tradition that has accepted PV in unions as a symbol of love. Generally, the other regions do not condone the act of PV in unions and that is why the frequency is limited. This is contradictory to the study carried out by Kishor and Johnson (2004) and Kishor and Bradley (2012) who argued that women who have ever experienced spousal violence and are poor are much more likely to live in rural areas. We realize that poverty triggers PV and causes injuries stress and depression in women thereby affecting their health. Since poverty is the trigger, women in non-poor urban areas are unlikely to suffer from PV since they are economically stable as compared to those in non-poor urban areas.

13.4.2.1.2 Emotional/Psychological Violence (EPV)

EPV signifies humiliating a woman in public; threatening to hurt or harm someone close to her; and insulting or making her feel bad about herself (Nmadu et al., 2022). Araya (2017) indicates that EPV by an intimate partner is associated with depressive episodes among RPUW. In our study, EPV goes beyond these to bullying, constant harassment, and life-threatening remarks against women as ascertained by 80.5% of the women (Table 13.2). This form of violence, which is recurrent in poor urban areas, is “hidden” and/or not exposed to society, and most women suffer and "die" in silence. The victims opined that their partners restrict and/or prevent them from seeing friends and visiting their families of birth, always control their movements, ignore them, or treat them with indifference. Their husbands also prevent them and/or get angry when they talk with other men, are suspicious that they are unfaithful, take very limited or no care of their financial needs, isolate, and disrespect them even in public places. Findings revealed that 54% out of 80.5% were forced and/or obliged into early marriages to much older men who see and treat them like children. This study falls in line with a study carried out by Abrahams et al. (2014), who said that poor urban women are likely to tolerate GBV. These findings oppose that of the UN-Habitat (2007), which stated that women as individuals and as urban dwellers (non-poor) are less likely to tolerate GBV. However, tolerating GBV is not voluntary but anecdotal. Poverty aggravates violence against women as attested by RPUW. This confirms our hypothesis that GBV against women in Cameroon is significantly influenced by location.

13.4.2.1.3 Sexual Violence (SV) or Sexual Abuse (SA)

Sexual violence is any sexual act or attempts to obtain a sexual act by violence or coercion, an act directed against a person's sexuality, regardless of the relationship to the victim in any setting (Araya, 2017; Malgesini et al., 2019), when the female partner does not want because she is afraid of what the partner might do (Nmadu et al. 2022). Table 13.2 reveals that 22.5% of RPUW suffer from SV. Although Ajah et al. (2014) argued that sexual violence was more common among rural women than among urban women, findings reveal that poor urban women in Cameroon also experience the same rate of sexual violence as rural women. The highest prevalence of SV in Cameroon has been recorded in the north west, south west, and far north regions of Cameroon due to the Anglophone crisis and Boko-Haram attacks that resulted in insecurity in these regions.

Nevertheless, women are most likely to be vulnerable to DV violence, especially in urban slums (Chant, 2013, Chant & Datu, 2011) and more severe in rural communities (NCADV; 2022) more specifically and with the focus squarely on physical and sexual violence. In this same line, Gonzales de Olarte and Gavilano (1999) and Tranchant et al. (2017) iterated that women are more likely to suffer from any type of domestic violence in rural areas. The injuries are substantial because rural areas are more likely to adhere to traditional gender roles and addressing domestic violence and sexual assault are lower priorities in rural communities (Gonzales de Olarte. & Gavilano, 1999). Avila-Burgos et al. (2009) supported the fact that poverty is an aggravating factor in relation to physical and sexual abuse. Nevertheless, our findings show that women residing in rural and poor urban areas are more by GBV than women who reside in non-poor urban areas where the main determinants are poverty and location.

13.4.2.2 Female Genital Mutilation (FGM)

FGM is a crime in Cameroon, but despite this, the practice has not yet been eliminated. Also known as Female circumcision or female genital cutting (FGC), it is a common practice in many societies in Sub-Saharan Africa (Kabeta, 2010), and it is a form of violence against women and girls according to the United Nations (UN, 2020). It includes procedures that intentionally alter or cause injury to female genital organs for non-medical reasons. Beyond extreme physical and psychological pain, the practice carries many health risks, including death (Malgesini et al., 2019). Girls go through genital mutilation/cutting because of the social consensus that female sexuality should be controlled and their virginity preserved until marriage. Men in some cultures usually will not marry girls who have not undergone the procedure as these women are viewed as unclean and sexually immoral (UN Millennium Project, 2005). In Cameroon, FGM is a form of GBVAW that is still practiced by some ethnic groups in the far north, south-west, and north-west regions. However, the practice is at a reduced rate (5%). The ethnic groups practicing this act believe that it is a way to keep women faithful to their husbands, reduce sexual immorality, and for aesthetic reasons. In this same line, Mutola et al. (2022) opined that this action is carried out to reduce sexual immorality among women, remove sexual ambiguity, and improve genital esthetics; it is a feministic symbol and cultural identity and a basis for resistance from government's socio-economic neglect. FGM is often performed without anesthesia under non-hygienic conditions by untrained practitioners and sometimes leads to fatal or serious health complications. This form of violence is only carried out in some rural areas; women in urban areas do not experience it because the milieu is highly socialized with people from different cultural backgrounds. The findings validate our first hypothesis.

13.4.3 Economic and Health Outcomes of GBV Against RPUW

Violence against women also has a profound impact on development (Krantz, 2002). Health, social, and economic consequences of GBWAV are enormous and affect individuals, families, and communities (ANROWS, 2015). The physical, mental, sexual, and reproductive health of millions of women and families are adversely affected by DV (Nmadu et al., 2022). In this study, it was revealed that RPUW (nine percent) had scars on their bodies from wounds gotten because of PV from their partners. A proportion of 18% was psychologically or emotionally disturbed by the constant violence they face leading to a depressive situation. Araya (2017), in this same line, concurred that the consequences of PV vary from mild physical injury to incapacitating disability and moderate to severe forms of emotional disturbances. This compounds their suffering and prolongs healing because they do not share their pains due to language barrier/illiteracy and for fear of being reprimanded by the condoning community. This emotional misery of RPUW affects those around them such as their children who feel inferior among their peers in the community; that is, health damages are not only encountered by women but also by those in their environment.

In Africa, early child marriage is associated with early pregnancy and childbirth damages reproductive organs with higher rates of HIV transmission than that of their unmarried counterparts (UNIFEM, 2005). The continuing prevalence of FGM, forced early marriage, wife inheritance practices, and prohibitions on land ownership continue to create serious health and economic disadvantages for women and girls (UN Millennium Project, 2005). In the context of Cameroon, early marriages caused 59% of women to drop out of school, and this limited their ability to control birth where they end up suffering with very young malnourished children whose age differences vary between 12 months and 18 months. It is a very challenging situation for the women whose health and that of their children are tampered with; 8% of respondents acknowledged the fact that they have lost some of their children due to uncontrolled child reproduction and lack of financial means to carter for them. Other health outcomes can include injuries and disabilities caused by violence, as well as sexually transmitted infections, unwanted pregnancies, involuntary abortions, illnesses, and chronic pain syndrome.

However, there is agreement that violence against women severely affects a woman's ability to participate fully and capably in reproductive and productive roles, and this negatively affects the household, community, and national well-being (Manjoo, 2011). In addition, according to Krantz (2002) and Morrison et al. (2007), when women experience widespread and repeated violence, they are unable to work or function effectively thereby perpetuating poverty. This is the same trend in our study, where poor urban women sometimes lost their menial jobs due to PV and EPV inflicted on them by their partners. Because a majority of the urban poor women have not received any formal education, they go in for jobs like house cleaners, baby seating, serving in bars/restaurants, and all the like; these jobs demand physical power, but once the women are physically disadvantaged, they cannot continue with their jobs coherently. This makes them lose their jobs because of inconsistency. These findings validate the second hypothesis of our study which states that; "the health outcomes of GBV against RPUW retards economic growth in Cameroon."

13.4.4 The Interlock Between Poverty and GBV Against RPUW

The relationship between poverty and men's perpetration of violence against women and girls is complex. This section of our study tries to draw a link between poverty and GBV against RPUW. Poverty leads to attacks on and abuse of women regardless of socioeconomic position (Mcilwaine & Data, 2003). It has been demonstrated that poverty constitutes a risk factor as regards the occurrence of PV in the household. On the other hand, poverty is a consequence of violence. DV (IPV) has health, and economic impacts on individual women, their families, and their communities, which reinforces poverty through multiple pathways (Gibbs et al., 2017). A number of empirical studies have shown that as a woman's income increases, domestic violence against her declines (Aizer, 2011). It should be noted that in Cameroon, DV sometimes causes injuries and illnesses in women that necessitate medical attention. Medical attention implies spending money in the hospital and reducing the available finances thereby increasing financial insecurity within households. More so, adverse health outcomes of GBV against RPUW put pressure on health facilities and are a socio-economic cost at the national level in relation to lowering productivity and affecting the creation of human and social capital. GBV against RPUW is in itself an indicator of blocked development as seen in our study. We note that poverty is a cause of GBV against RPUW directly and/or indirectly on one hand, and on the other hand, GBV against RPUW causes and/or exacerbates poverty or financial insecurity. Poverty and GBV against RPUW interact in a vicious circle as revealed by our studies (Fig. 13.4). GBV against RPUW significantly causes poverty and vice versa as we have seen in our discussions.

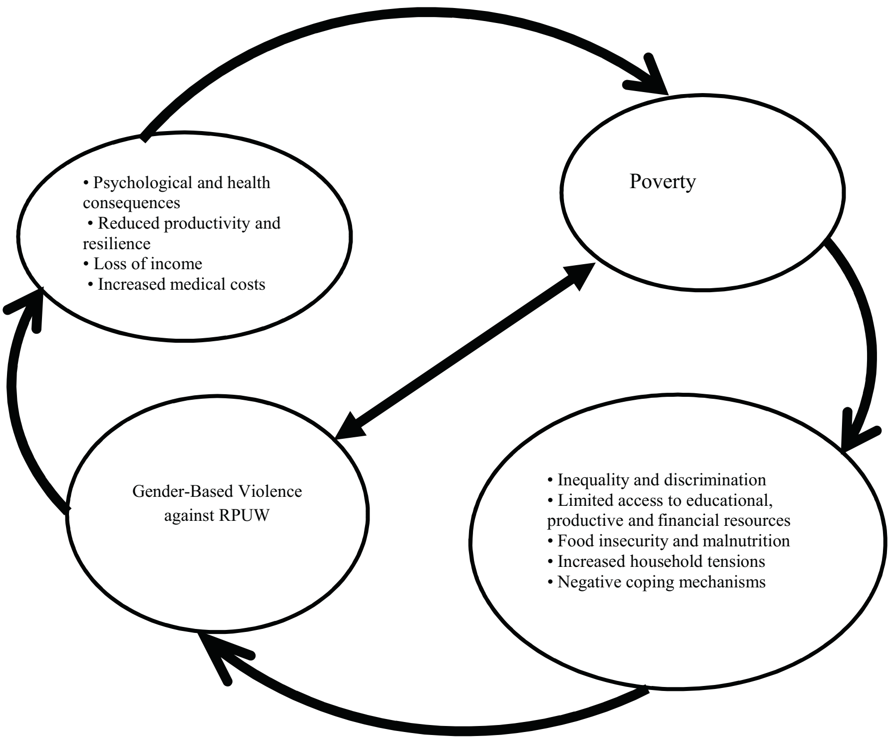

Fig. 13.4 Interrelationship between poverty and GBV against RPUW. (FAO, 2018 and field work, 2022)

Figure 13.4 clearly illustrates the link between poverty and GBV against RPUW, which is directly and/or indirectly. The direct link shows that GBV against RPUW causes health injuries and psychological imbalances that require medical attention thereby spending money on the treatment of victims meanwhile the money could have been used for the upkeep of the family. This leads to household financial insecurity and/or poverty. On the other hand, it is noted that RPUW because of financial lack/poverty suffer GBV from their spouses because they depend financially on their husbands. It was observed that the RPUW accept/tolerate violence against them because they cannot stand financially on their own. Moreover, it has been argued that at times, men are violent against their partners when they are unemployed and lack money to provide for the financial upkeep of their families because they have a feeling of losing the house head position or "masculinity" and respect from their partners.

Poverty also causes GBV against RPUW in an indirect manner where poverty is the root cause of inequality/discrimination; limited access to educational, productive, and financial resources; food insecurity and malnutrition; and increased household tension. That is, these aspects heighten gender issues within regions thereby causing violence against RPUW who are regarded as inferior to men. Moreover, GBV against RPUW, more or less, leads to psychological and health consequences; reduced productivity and resilience; loss of income via replacement of household equipment destroyed when PV is exercised, and increased medical costs. Thus, this leads to or increases the level of poverty within households, communities, and the Nation.

13.5 Conclusion

The purpose of this study was to identify and evaluate the link existing between poverty and GBV against RPUW in Cameroon. The main aim of this chapter was to identify the causes and assess the health issues of GBV against RPUW in Cameroon. This study revealed that the causes of GBV against RPUW in Cameroon were connected to their location. That is, women living in rural and poor urban areas experienced GBV considerably influenced by their location (rural and poor urban areas) when compared to women living in non-poor urban areas. Poverty and/or economic dependency of women on men, rigid gender roles, and language barrier/illiteracy were the major causes of GBV against RPUW in Cameroon, and it should be noted that these determinants are attributes of rural and poor milieus. Analyzing GBV against RPUW and its health outcomes, the chapter proves that GBV against RPUW causes health injuries, illnesses, and psychological imbalances among others that require medical attention. However, families spend money on the treatment of victims when the money could be used for other purposes; this leads to household financial insecurity and/or poverty. Moreover, the psychological and health consequences of GBV against RPUW reduce productivity and resilience; loss of income especially for the replacement of household equipment destroyed when PV is exercised. Consequently, GBV against RPUW is a major constraint to women's full participation in the economic growth of society.

We suggest that poverty alleviation strategies be implemented alongside some best practices to raise awareness about GBV in rural and poor urban communities:

- Ensure that action is taken to aid and/or heal survivors or victims of GBV
- Consider organizing outreach sessions within the villages to raise awareness about GBV. Use meeting ("njangi") days, and markets days to talk and sensitize the population in their mother tongues
- Encourage RPUW to become independent/autonomous by creating activities that will contribute to empowering, and reducing GBV against them

Thus, improving the health of victims of GBV will render them strong, active, and more productive leading to the development of health, poverty alleviation, and inclusive economic development in Cameroon and Africa as a whole.

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Chapter 14
Menstrual Hygiene Management in the Context of Water, Sanitation and Hygiene (WASH) Policies – A Case of Schools in Nigeria

Ademola Luqman Adeagbo

14.1 Introduction

There is a relationship between health and development. The health status of individuals influences their level of productivity, income generation, poverty incidence and contribution to local and national economy. Health is recognized as both an enabler for sustainable development and an end in itself, hence its inclusion as the third goal among the 17 Sustainable Development Goals (SDGs), though it is also linked to the other 16 SDGs. Thus, ensuring the health and well-being of all is essential to poverty eradication efforts and achieving sustainable development (Global Affairs Canada, 2017). Chen-Feng et al. (2021) observed that a moderately human capital condition improves the workforce's abilities, efficiency and quality of life and that a country's condition of health impacts economic development in a multiple of ways such as enhancing value added in manufacturing and services and creation of innovation. Thus, improvement in health is expected to contribute to community, regional and national development.

Menstrual hygiene management (MHM) is a health component, specifically sexual and reproductive health. It is in this regard that the World Health Organization (WHO) (2022) advocated menstrual health to be recognized, framed and addressed as a health and human rights issue rather than a hygiene issue. The organization called for three actions in this regard. First, menstruation should be regarded as a health issue with physical, psychological and social dimensions that should be addressed. Second, that menstrual health should be understood through the perspective of ensuring access of menstruating women and girls to relevant information and education, required menstrual products and adequate water, sanitation and disposal

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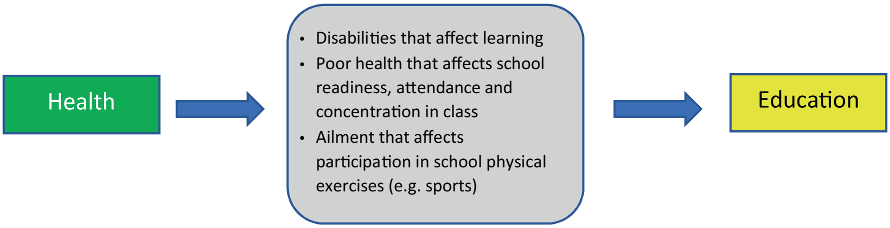

Fig. 14.1 Influence of health on education. (Adapted from Midford et al., 2020)

facilities; they must have access to competent and emphatic care when required and must be able to live and work in an environment friendly to menstruation and its management. Thirdly and finally, there should be adequate provision for relevant menstrual hygiene management in relevant sectoral workplans and budgets with effective framework for performance management (WHO, 2022).

Regarding menstrual hygiene as a health issue, there is the need to pay adequate attention to the issue at the school level due to the effect of health on education. The relationship between health and education is interdependent, but our concern here is the impact of pupil/students' health on education. According to Midford et al. (2020), a child's state of health, both physical and emotional, influences their readiness for school and their level of school attendance. Other effects include ability to learn and participate in school activities like sports and environmental sanitation activities. This is illustrated in Fig. 14.1. The state of menstrual hygiene management is likely to affect students/pupils with regard to learning ability, school readiness, attendance, concentration and effective participation in school activities.

Since the status of health influences education, development and economic prosperity, it is expected that the situation of health, in this regard menstrual hygiene management, should attract adequate policy measure. According to the World Bank (2022), some requirements are needed for girls and women to effectively manage their menstruation. These include access to water, sanitation and hygiene (WASH) facilities, affordable and appropriate menstrual hygiene materials, information on good practices and a supportive environment for management. In essence there is a need for the design and implementation of a comprehensive WASH policy that will recognize these issues and provide workable strategies for effective management of menstrual hygiene.

Some factors that can cause menstrual health and hygiene needs to go unmet include gender inequality, discriminatory social norms, cultural taboos, poverty and lack of toilet (UNICEF, n.d.). A comprehensive WASH policy is expected to recognize all these factors and address them. Since Nigeria is a country with diverse physical terrains, social norms, cultures and tradition, these factors are likely to vary from region to region; hence, there is the possibility of WASH policies and menstrual hygiene practices varying from region to region. This fact underlies the choice of two distinct study locations within Nigeria for the discussion in this chapter. Specifically, this chapter gives a general overview of WASH policies and strategies in Nigeria and attempts to describe the situation in two contrasting geographical contexts, Bauchi and Lagos States, with emphasis on how the policies reflect in the practice of menstrual hygiene management in schools in the selected locations.

14.2 Menstrual Hygiene: Definition of Concepts

14.2.1 Adolescence

Adolescence is the phase of life between childhood and adulthood, from ages 10 to 19 (WHO, 2023). At this stage of human development, the foundation of good health is laid. Among features associated with adolescence are rapid physical, cognitive and psychosocial growth, which affects how adolescents feel, think, make decisions and interact with the world around them.

14.2.2 Menstruation

Menstruation or menses is the natural bodily process of releasing blood and associated matter from the uterus through the vagina as part of the menstrual cycle (UNICEF, 2019). It is the process by which the uterus sheds its lining, marking the beginning of a new menstrual cycle, and usually occurs once a month in women of reproductive age (Dhanorkar, 2023). It occurs for between 2 and 7 days.

14.2.3 Menstruation Cycle

According to Menstrupedia (2023), menstruation occurs when the egg is not fertilized and pregnancy does not occur, the uterine lining is shed and it exits the body through vagina as a mixture of blood and tissue over a course of 3–7 days. The cycle starts over again with an egg that begins to mature in one of the ovaries and the length of the cycle is generally between 21 to 35 days. The phases of menstrual cycle are as illustrated in Fig. 14.2.

14.2.4 Menstruation Hygiene Management

Menstrual hygiene management (MHM) is defined as: ‘women and adolescent girls using a clean menstrual management material to absorb or collect blood that can be changed in privacy as often as necessary for the duration of the menstruation period, using soap and water for washing the body as required, and having access to

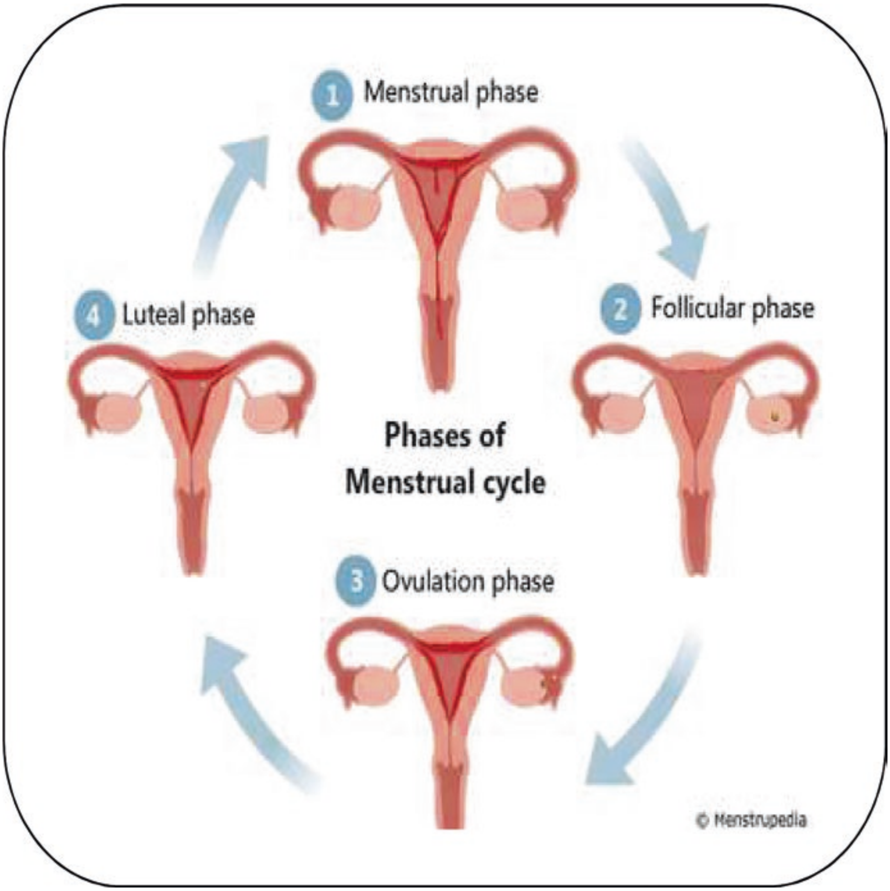

Fig. 14.2 Phases of menstrual cycle. (Menstrupedia, 2023)

facilities to dispose of used menstrual management materials' (WHO and UNICEF, 2014). Holistically, MHM is about the following:

- Articulation, awareness, information and confidence to manage menstruation with safety and dignity using safe hygienic materials
- Have access to adequate water and agents and spaces for washing and bathing and
- Disposal of used menstrual materials with privacy and dignity

As further described by Menstrupedia (2023), MHM involves measures taken to deal with menstrual flow and to maintain general hygiene, which include the following:

- Managing menstrual flow to prevent menstrual fluid from soiling the clothes
- Maintaining proper hygiene and cleanliness
- Eating a balanced diet to provide the body essential nutrients
- Maintaining an active lifestyle while avoiding stress and tension

14.3 WASH Policies and Strategies in Nigeria

14.3.1 National Water Supply and Sanitation Policy (2000)

The national water supply and sanitation policy (2000), emphasizes provision of sufficient potable water and adequate sanitation to all Nigerians in an affordable and sustainable way. The main objective of the policy is to increase service coverage for water supply and sanitation nationwide to meet the level of socio-economic demand of the nation. Some of the proposed strategies include: establishing a data management system on water supply and sanitation; prevent wasteful water use and control water leakage; promote social marketing; strengthen water supply and sanitation training institutions; among others.

14.3.2 National Action Plan for Revitalization of Nigeria's WASH Sector

There is the National Action Plan for Revitalization of the Nigeria's WASH sector (FRN, 2018), which is a 13-year Revitalization Strategy aimed at ensuring that all Nigerians have access to sustainable and safely-managed WASH services by 2030 in compliance with the Sustainable Development Goals (SDG) for water (Goal 6.1) and Sanitation (Goal 6.2). The Revitalization Strategy is to strengthen and expand Nigeria's WASH services while improving their effective and sustainable management. Some of the key objectives of the Action Plan are to: clarify the roles of federal, state, and local governments in water supply and sanitation service provision; establishment of the National WASH Fund; institutionalize sanitation as a necessary counterpart to water supply; and strategize to improve rural water supply provision, among others.

On sanitation, the vision of the Action Plan is that by 2030, every Nigerian will have access to safely managed sanitation and hygiene facilities in cities, small towns, and rural areas. Some of the actions recommended for participating state governments are: enforcement of building codes and related legislation regarding minimum number of sanitation facilities and to enact new codes where existing codes are inadequate; improving access to sanitation and hygiene services in public spaces in preparation for legislation against open defecation and urination; and development of state Roadmaps for the elimination of open defecation.

14.3.3 National Hygiene Promotion Strategy in Nigeria

The overall hygiene promotion strategy includes various aspects of hygiene promotion including MHM. With regard to MHM, it states that MHM in primary schools and communities will be an integral part of an overall hygiene promotion in Nigeria. It will be first introduced in communities and then to primary schools. On approaches to be adopted, it states since MHM in schools and communities is an integral part of hygiene promotion strategy, a specific approach is needed for its implementation. The idea is behaviour change in MHM areas in the communities before it is introduced in the catchment primary schools. The implementation of hygiene promotion activities was from 2015 to 2022.

14.3.4 Partnership for Expanded Water Supply, Sanitation and Hygiene (PEWASH)

The PEWASH (FRN, 2016) programme aims to prioritize the achievement of 100% access to water and improved sanitation in rural areas by the year 2030 and eliminate open defecation by 2025. This is in recognition of the fact that access to WASH in small town/urban areas and in all Public Institutions (Schools, Health Institutions, Markets, Offices, Public spaces, etc.) will need to be achieved in order to meet the SDG-6 targets 6.1 and 6.2. However, the PEWASH programme is limited to the rural WASH.

14.3.5 Guidelines for Hygiene Promotion 'In and Through' Schools in Nigeria

This is a very important document that spells out implementation strategies for hygiene promotion activities 'in and through schools' (FRN, n.d). It recognizes children as agents of change with the expectation that children motivate members of their families to adopt good hygienic behaviours. The guidelines propose an interaction between school teachers, pupils, parents and other community members to generate an environment in favour of complete sanitation coverage. The guidelines propose a 5-star approach to hygiene promotion approach with the five-star school having established MHM awareness and child-to-family and child-to-community approach. With respect to MHM, the guideline is about routine education on Menstrual Hygiene Management (for Classes 5 & 6).

14.4 Geography and WASH Policy and Situation in Study Locations

14.4.1 Geography

The geography of the study locations has relevance for the state and implementation of WASH policies in the two locations of interest to this chapter. For example, physical terrain is a determinant factor for the type of toilets to be constructed and their sustainability. Further, the population characteristics of the states determine demand for WASH facilities, while the culture and religion of the population influence people's perception of menstruation and its management. Economic activities in the locations determine income generation and affordability of ownership of WASH facilities. The educational characteristics of the population, especially literacy level, underpin their understanding of the importance of good WASH practices – the use of toilet, good water management practices and handwashing with soap and water. The status of access to water and sanitation also gives an idea of the WASH situation in the state. In the context of the foregoing, we highlight some geographic characteristics of both Bauchi and Lagos states. As a background, Bauchi is located in North-Eastern Nigeria while Lagos is a coastal state in South-Western Nigeria.

Bauchi state spans two distinctive vegetation zones, namely, the Sudan savannah, which covers the southern part of the state, and the Sahel savannah, which manifests from the middle of the state as one moves from the southern part of the state northwards. The southern part of the state is mountainous, while the northern part is sandy. The rainy season months are from May to September and monthly rainfall ranges from 0.0 mm in December and January to about 343 mm in July. The state, according to the 2006 Nigerian population census, had a population of 4,653,066, making it the 7th most populous states among the 36 states in Nigeria. The male population was 2,369,266 (50.9%), while female population was 2,283,800 (49.1%). Nearly 41% of the population are aged 18 to 50 (National Population Commission (NPC) [Nigeria] and ICF, 2019). The population is spread over 49,119 km^2, giving a population density of 95/km^2.

Bauchi state has a total of 55 ethnic groups in which Hausa, Fulani, Gerawa, Sayawa, Jarawa, Kirfawa, Turawa, Bolewa, Karekare, Bufawa, Warjawa, Zulawa and Badawa are the main groups. There are cultural similarities in the people's language, occupational practices, festivals and dress. Islam is the predominant religion in the state. The state is an agricultural state. Its vast fertile soil is an added advantage for agricultural products, which include maize, rice, millet, groundnut and guinea corn. Irrigation farming is practiced and supported by the use of dams like Balanga dam, etc. Cattle and other livestock are also reared in the state. The state also has manufacturing industries in the area of Iron and Steel, Water, Ceramics, Food and Beverages, etc., According to National Demographic and Health Survey (NDHS, 2019), the proportion of literate women aged 15 to 49 years in Bauchi state was 26.4%, while the corresponding proportion for men was 47.5%. Primary school net attendance ratio was 46.9 (male – 48.1 and female – 45.8). The Gender Parity

Index for Primary School attendance was 0.95%. Similarly, the secondary school Net Attendance ratio was 28.2 (male – 29.2 and female – 27.2). The Gender Parity Index was 0.93.

Lagos state has two main seasons throughout the year. The rainy season occurs between April and mid-November, while the dry season is experienced between November and March. The state has coastal environment with three main vegetation types-mangrove, secondary rain forest and freshwater swamp. According to the 2006 population census, Lagos had a population of 9,013,534, estimated to be over 24.6 million by 2015. With a total land area of 3559 km^2, Lagos is the most densely populated state in Nigeria. More than 52% of its inhabitants are aged 18 to 50 years (National Population Commission (NPC) and ICF, 2019). Lagos state is inhabited by many indigenous groups, majority of whom are the Yorubas. The indigenous inhabitants are the Aworis and Ogus in Ikeja and Badagry Divisions, the Remos and Ijebus with pockets of Eko-Awori settlers in Ikorodu and Epe Divisions. The state also has large population of Nigerian non-native ethnic groups including Edo, Ibibio, Igbo, Fulani, Ijaw, Nupe and Hausa. Non-Nigerian natives Lagos state include the Saro (Sierra Leonean), Amaro (Brazilians) and those from Togo, Ghana and Cameroon. The popular religions in Lagos state are Christianity, Islam and Traditional belief.

Lagos is a major financial centre of the country and one of the largest economies in Africa.

The state is a financial hub with the headquarters of all major banks in Nigeria. Fishing and farming are the major occupations of the indigenous population, though the state is a commercial city with less arable land for agriculture. The major crops cultivated include cassava, maize, plantains, potatoes, rice, sorghum, soybeans, sweet potatoes, wheat and yams. According to National Demographic and Health Survey (NDHS, 2019), the proportion of literate women aged 15 to 49 years in Lagos state was 85.3%, while the corresponding proportion for men was 93.0%. Primary school net attendance ratio was 74.0 (for male, 75.5 and for female, 72.7). The Gender parity Index was 0.96. Similarly, the secondary school Net Attendance ratio was 69.7 (for male, 70.5 and for female, 69.0). The Gender parity index was 0.98.

14.4.2 WASH Policies and Situation

There is the Bauchi State WASH Policy of 2019 (Bauchi State Government, 2019). The goal of the policy is to ensure the provision of safely managed WASH services to all residents through participatory investment and management by stakeholders to guarantee available, accessible, affordable, reliable and sustainable WASH service delivery. The specific objectives include: provision of at least a basic WASH service to the residents of Bauchi state using appropriate technologies with low maintenance costs; ensuring incremental approach in WASH access from safely managed services by at least 70% of residents in the state; reduction in WASH disease burden; and stimulating incremental investment and funding, among others. Some of the key targets include: increase basic water supply services to 85% (from 60.2%) of the population by 2025 and 100% by 2030; increase basic sanitation service to 75% (from 37.5%) of the population by 2022 and 100% by 2030; and additional 50% of the population adopt basic hygiene practices by 2025, increase to 75% by 2030. The key components of the policy are: water supply (urban and small-town water supply; rural water supply); sanitation and hygiene promotion; and health and hygiene promotion.

Presently, Lagos state is finetuning its WASH policy. It is not yet finalized. There is Lagos State Environmental Management and Protection Law 2017, which is about the general management of the environment and environment related matters in Lagos state (Lagos State Government, 2017). The objectives are to: provide a clean, safe and healthy environment for all residents in the state and enable citizens access the various public amenities or segments of the environment for recreational, educational, health, cultural and economic purposes. The Law is not basically about water, sanitation and hygiene. However, the State Ministry of Environment and Water resources through the Office of Environmental services undertakes activities towards improving sanitation and hygiene situation in the state. Such activities include: advocacy and enlightenment (public enlightenment and social marketing of sanitation; Promotional and Media Campaign on Eradication of Open Defecation); standardization and coordination (promotion of improved technology through sanitation marketing; approval and regularization of public toilet operation); and bridging of infrastructural gaps (provision of public toilets and rehabilitation of existing facilities in public places), among others.

Among the general population, a little over 61% of households in Bauchi had improved sanitation facilities and used improved drinking water sources. As shown in Table 14.1, more than 90% of the household toilets had privacy. However, more than 70% of the hand washing facilities were not available on premises, while a little above one-quarter of the toilets were located within own dwelling. Drinking water sources accessible within the premises were less than 5%. In Lagos, more than 90% of the households were using improved sanitation facilities and improved

Table 14.1 Water, sanitation and hygiene in study locations

WASH indicator	Bauchi	Lagos
% of household members using improved sanitation facility	61.5	93.5
% of household latrines located within own dwelling	25.3	61.8
% of households toilets with privacy	92.0	97.7
% of households where handwashing facility is not available on premises	74.9	58.7
% of household members using improved drinking water sources	75.5	98.0
% of household members using improved drinking water source accessible within the premises	3.3	88.1
% of household members using basic water supply, basic sanitation and hygiene services	14.1	25.5

Source: Federal Ministry of Water Resources (FMWR), Government of Nigeria, National Bureau of Statistics (NBS) and UNICEF (2022) drinking water sources. More than 90% of the toilet also provided privacy. Nearly 62% of the household latrines were located within own dwelling, while more than 80% of the improved sources of drinking water were located within the premises. However, close to two-fifths of the handwashing facilities were not available on premises. These figures show that on the indicators, Bauchi state had a poorer performance compared to Lagos and that in both states, WASH policy targets have not been met adequately. How these performances reflect on the MHM practices in schools in both states is examined in the succeeding section of this chapter.

14.5 Menstrual Hygiene Management Practices in Bauchi and Lagos Schools

Data employed for the discussion in this section were extracted from the WASHNORM 2022 report (FMWR, NBS, 2022) and complemented by qualitative data from earlier studies by this author in Bauchi and Lagos states.[1]

14.5.1 WASH in School Environment

Water Facilities

Schools are expected to provide adequate WASH facilities for the use of students and other users of educational facilities. Water, toilet and handwashing facilities are expected to be available, accessible and functional. The state of water facility is presented in Table 14.2. The proportion of schools with water facilities in Lagos state is greater than that of Bauchi state and above the national average unlike that of Bauchi state. With regards to functionality, the proportion of schools in Lagos state with water facilities which currently supply water is slightly greater than that of Bauchi state. Bauchi and Lagos states' proportions are above the national average. On accessibility, the proportion of schools with water sources accessible to people with disabilities (PWDs) is greater than that of Lagos state and above the national average unlike that of Lagos state. The implication is that schools in Lagos state have better water facility situation with regard to availability and functionality, while the situation in Bauchi is better with regard to accessibility to PWDs. Water facilities and sources are illustrated in Figs. 14.3, 14.4 and 14.5.

[1] 1. Research on Menstrual Hygiene Management Programmes in Nigeria, Understanding the socio-economic, and political factors, challenges and opportunities in Bauchi, Benue and Plateau states. Prepared for WaterAid, Nigeria. 2015.

2. Formative Research on Current Sanitation and Hygiene Behaviours in Ikorodu North and Ojodu Local Council Development Areas (LCDA), Lagos State, Nigeria. Prepared for Water Aid, Nigeria. 2022.

Table 14.2 Availability and accessibility of water facility to PWDs

	Bauchi	Lagos	National
Availability of water facility			
Available	52.1	88.0	64.4
Not available	47.9	12.0	35.6
Water from main source currently available			
Available	82.4	83.8	76.8
Not available	17.6	16.2	23.2
Accessibility of water source to PWDs			
Accessible	55.4	40.1	48.6
Not accessible	44.6	59.9	51.4

Fig. 14.3 Waterpoint in one of the schools in Bauchi State

Sanitation Facilities

Schools are expected to have toilet facilities, which must be functional, clean and provide adequate privacy and be safe for the use of students/pupils and other users of the school facility.

As presented in Fig. 14.6, more than 90% of the schools in Lagos, compared to about 60% of those in Bauchi, have toilet facilities. The proportion of schools with toilet facilities in Lagos is above the national average, while that of Bauchi is slightly below. There are various types of toilet facilities and it is desirable that schools provide improved ones. As presented in Table 14.3, all the schools in Bauchi state and almost all of those in Lagos state have improved toilet facilities. However, there

Fig. 14.4 Water Facility in one of the schools in Lagos state

are categories of improved toilet facilities and the most desirable is flush/pour flush toilets. More schools in Lagos, compared to Bauchi, have this type of toilet. The proportion of Lagos schools with this type of toilet facility is above the national average compared to that of Bauchi state. A toilet facility is illustrated in Fig. 14.7.

Availability of toilets in schools is important, but they must be useable and accessible to all categories of users including people with disabilities (PWDs). As presented in Table 14.4, all the schools in Bauchi state and close to 90% of those in Lagos state have at least one useable toilet and these figures are above the national average. More than half of the schools in Bauchi and a little above two-fifths of those in Lagos have at least one toilet accessible to PWDs and these figures are also above the national average. The implication is that there is the likelihood of more schools in Bauchi state having more useable toilets, which are also more accessible to PWDs.

Fig. 14.5 Students fetching water to Head-Teachers Toilet in one of the schools in Lagos

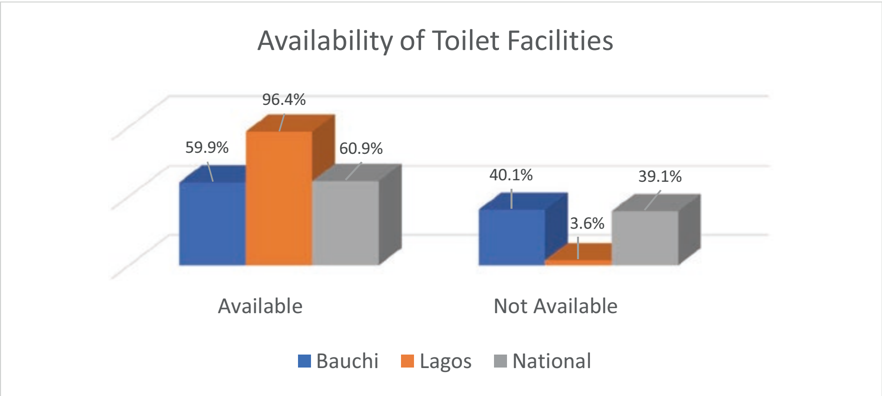

Fig. 14.6 Availability of sanitation facilities in schools

Toilets may be available, useable and accessible but may not be used if they are not clean, hence the importance of having clean toilets. However, it appears the issue of cleanliness of latrines becomes critical generally, though the situation appears better in Lagos compared to Bauchi. As illustrated in Fig. 14.8, more schools in Lagos state (47.3%) compared to Bauchi (3.6%) have clean toilets and the proportion of the schools with clean toilets in Lagos is above the national average. An example of dirty toilet facility is illustrated in Fig. 14.9.

Table 14.3 Type of sanitation facility

	Bauchi	Lagos	National
Improved			
Flush/pour flush toilets	6.2	85.1	41.0
Pit latrine with slab	93.8	12.3	45.8
Compost toilet	0.0	1.4	0.6
Un-improved			
Pit latrine without slab	0.0	1.2	11.7
Others	0.0	0.0	0.9
Total	**100.0**	**100.0**	**100.0**

Fig. 14.7 Toilet facility in one of the schools in Bauchi state

Table 14.4 Usability and accessibility of toilet facilities to PWDs

	Bauchi	Lagos	National
Usability of toilet/latrines			
At least one useable	100.0	89.9	73.0
Non-useable	0.0	10.1	27.0
Total	100.0	100.0	100.0
Accessibility to PWDs			
At least one accessible	57.4	42.6	42.3
Not accessible	42.6	57.4	57.7
Total	100.0	100.0	100.0

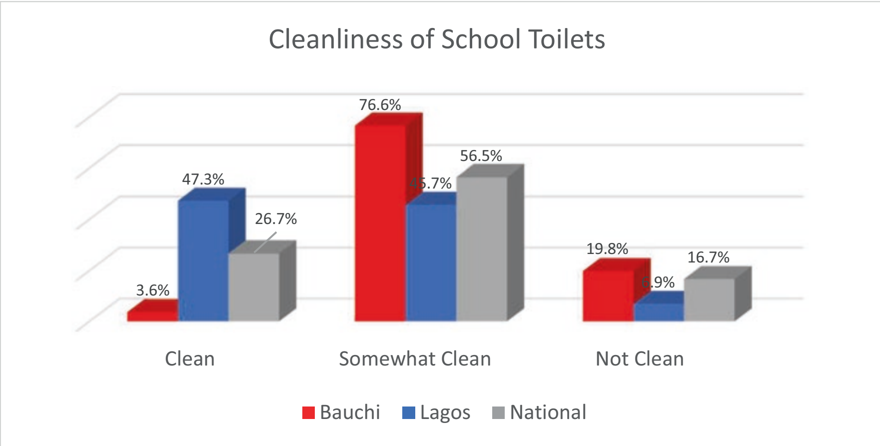

Fig. 14.8 Cleanliness of school toilets

Handwashing Facilities

Handwashing with water and soap is a very critical hygiene practice; thus, schools are expected to have handwashing station at an accessible location with regular supply of clean water and soap for effective handwashing.

As presented in Table 14.5, the situation with regard to availability of handwashing facilities appears better in Lagos state compared to Bauchi state. More than 80% of the schools in Lagos state, compared to about 57 per cent of those in Bauchi state, have handwashing facility, though the situation in the two states is above the national average. With regard to accessibility of the handwashing facilities to PWDs, more schools in Bauchi state have handwashing facilities accessible to PWDs compared to Lagos. The proportion of the schools in Bauchi state is also above the national average while that of Lagos is below. Availability and accessibility of handwashing facilities should be complemented with availability of water and soap which are the materials needed for effective handwashing. Table 14.5 further reveals that Lagos state has more schools that have handwashing facilities with water and soap compared with those in Bauchi state. The proportion of schools in this category is also above the national average.

Fig. 14.9 Toilet used but not flushed in one of the schools in Lagos state

Table 14.5 Availability and accessibility of handwashing facilities to PWDs

	Bauchi	Lagos	National
Availability of handwashing facility			
Available	57.1	83.2	51.4
Not available	42.9	16.8	48.6
Total	100.0	100.0	100.0
Accessibility to PWDs			
Accessible	65.4	40.0	50.3
Not accessible	34.6	60.0	49.7
Total	100.0	100.0	100.0
Availability of soap and water			
Yes, water and soap	56.1	81.2	67.1
Water only	27.4	17.3	24.9
Soap only	0.0	0.1	0.9
Neither water nor soap	16.6	1.4	7.1
Total	100.0	100.0	100.0

By implication, with regards to handwashing, Lagos state fairs better than Bauchi in the aspects of availability of handwashing facilities and availability of soap and water but the situation in Bauchi is better in the aspect of accessibility of handwashing facility to PWDs. An example of handwashing facility is illustrated in Fig. 14.10.

Fig. 14.10 Toilet and handwashing facilities in one of the schools in Lagos state

14.5.2 Menstrual Hygiene Management (MHM)

Availability of Water and Soap for MHM

Availability of WASH facilities is primary for effective MHM, but there are MHM-specific facilities that must be made available to complement available WASH facilities. These are examined in this section. Water and soap must be available for girls to bath/clean up when they change menstrual materials and to wash the materials as may be applicable. The extent to which these are available in schools in the two states is illustrated in Fig. 14.11. More schools in Lagos (58.6%), compared to Bauchi (29.5%), make provision for water and soap for MHM. The proportion of these schools in Lagos is above the national average while that of Bauchi state is below. This suggests that students in Lagos state schools are more likely to experience effective MHM compared to those in Bauchi state.

Provision of Menstrual Hygiene Materials

Materials used for managing menstruation include pad, cloth/rag, tissue paper, and foam. However, students prefer pad. Availability and affordability of materials are very critical for effective MHM. As illustrated in Fig. 14.12, provision of MHM materials appears not to be a common practice among schools in the country.

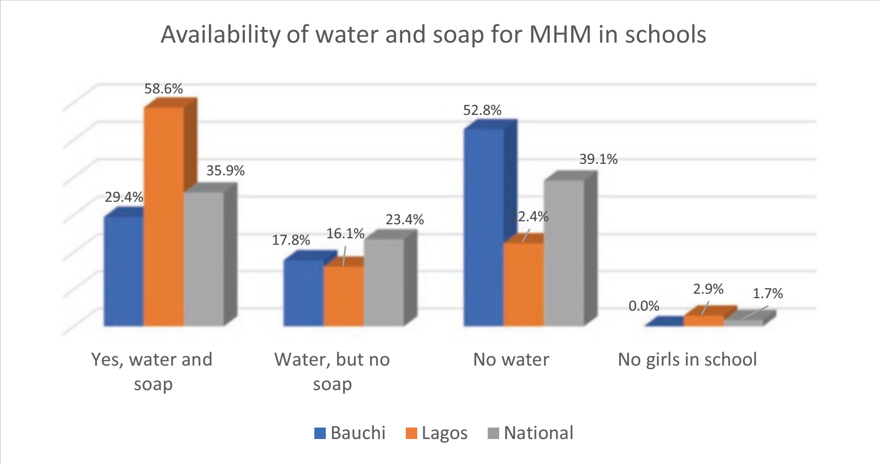

Fig. 14.11 Availability of water and soap for MHM in schools

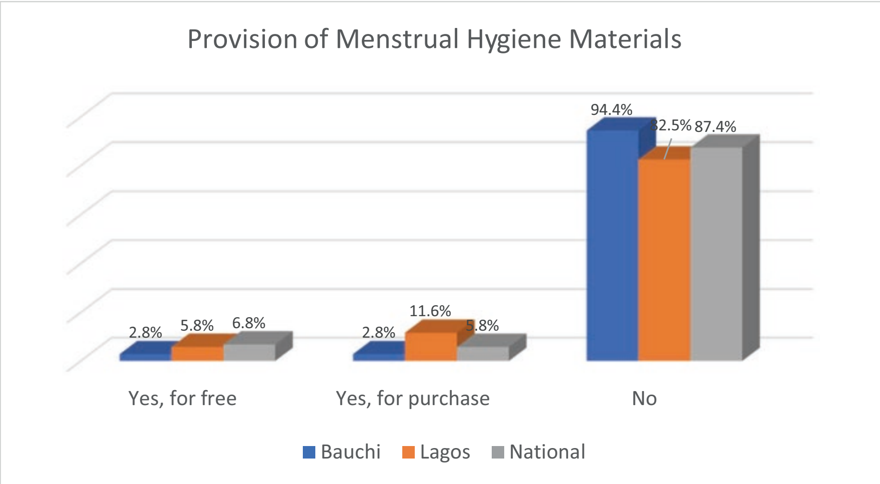

Fig. 14.12 Provision of menstrual hygiene materials in schools

However, more schools in Lagos state provide menstrual hygiene materials compared with the situation in Bauchi state. A case of an NGO donating menstrual pads is illustrated in Fig. 14.13.

> "School does not provide sanitary pads but some NGOs have been coming to distribute pads to students. I put used pad in my bag and dispose of it when I get home. I don't like to dispose of it in school because people may see me when I want to throw it away" (A Senior Secondary School Student in Lagos).

Fig. 14.13 Kotex Sanitary pads produced by Kimberly and donated to one of the schools in Lagos

Table 14.6 Provision of storage and disposal facilities for menstrual hygiene wastes

	Bauchi	Lagos	National
Covered bins for menstrual hygiene Management in Girls' toilet/latrine			
Available	9.0	46.1	24.4
Not available	91.0	53.9	75.6
Total	100.0	100.0	100.0
Disposal mechanism for menstrual hygiene waste			
Available	8.4	41.8	21.9
Not available	91.6	58.2	78.1
Total	100.0	100.0	100.0

Provision of Storage and Disposal Facilities for Menstrual Hygiene Wastes
Very important aspects of effective MHM are appropriate storage and effective disposal of used menstrual hygiene wastes like pads, tissue paper, cloth/rag, foam, among others. As presented in Table 14.6, generally, the proportion of schools providing covered bins for storage of used menstrual materials is very low, which suggests it is not a common practice among the schools in the country. However, the situation in Lagos is better compared with Bauchi. More than two-fifths of the schools in Lagos provide covered bins for storage of used materials as against Bauchi's less than 10%. The proportion of schools in Lagos is above the national

Fig. 14.14 Used sanitary pads dropped in the toilet of one of the schools in Lagos state

average. The case of availability of disposal mechanism for menstrual hygiene waste is similar. The practice is not common generally but much better in Lagos state, and above two-fifths of the schools have disposal mechanism in place compared to less than 10% of those in Bauchi state and above the national average of a little above one-fifth. An example of lack of storage facility for used pads is illustrated in Fig. 14.14.

Privacy and Security

Girls want to have their privacy when fixing or changing menstrual materials as well as have a sense of security. Thus, toilets they will be willing to use must provide privacy and be safe. As presented in Fig. 14.15, majority of the schools, at least six out of every seven in Bauchi and Lagos states, provide full privacy. Corroborating this, as further illustrated in Fig. 14.16, in at least six out of every ten schools in Bauchi and Lagos states, there is perception of full privacy and all the girls feel secure. In both cases, the proportion of schools is higher in Lagos state than in Bauchi state and is also above the national average. What this implies is that one, most toilets have enclosed superstructure-roofed, walls without cracks and doors with inner lock and two, while the privacy and security are generally better, Lagos state still stands out. Examples of toilet facilities are illustrated in Fig. 14.17 and 14.18.

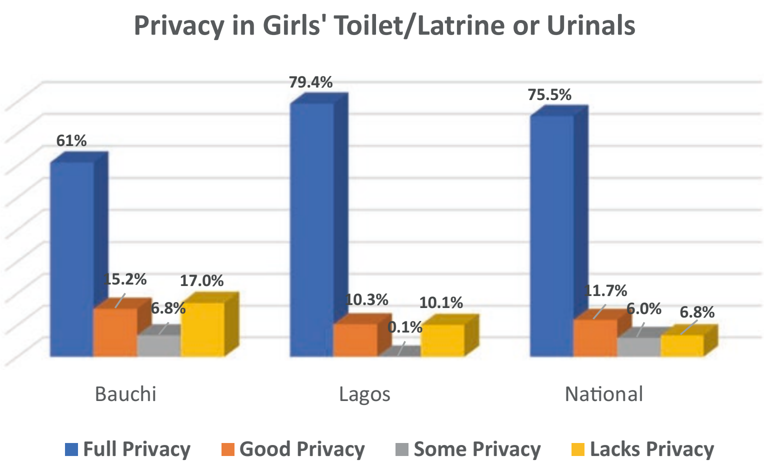

Fig. 14.15 Privacy in girls' toilet/latrine or urinals

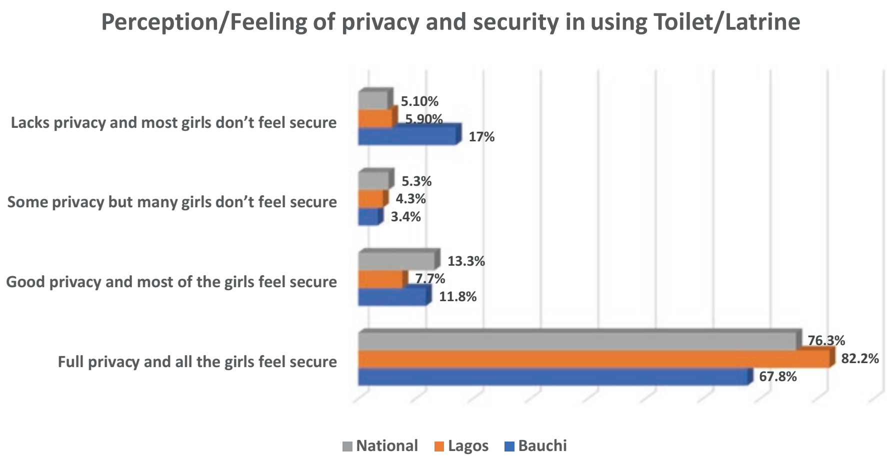

Fig. 14.16 Perception/feeling of privacy and security in using toilet/latrine

14.6 Linking Policy with Practice

Generally, policy thrusts and strategies are about the general WASH situation with regard to provision of water facilities, toilets and handwashing facilities as contained in Bauchi State Water and Sanitation Policy and the various strategies being implemented by the Office of Environmental Services in the State Ministry of Environment in Lagos state. This, by extension, has been responsible for the state of WASH facilities in schools. On the general WASH situation in schools, the linkage between WASH policies and practice of good WASH practices in schools may be obscured. This is because these policies are too generic. However, there are other

Fig. 14.17 A female toilet in one of the schools in Bauchi state

Fig. 14.18 Another toilet facility in one of the schools in Bauchi state

interventions by NGOs and development partners in collaboration with relevant state and local government agencies. Very prominent among such partners include UNICEF and WaterAid Nigeria. Several of these interventions are about improved WASH practices in schools. The situation of WASH practices in each of the states depends on the willingness and capacity (especially funding and human resource) of the state to partner with such collaborators. This could be a factor responsible for the better situation of School WASH in Lagos, compared to Bauchi state.

With specific reference to MHM practices, specific policy thrusts and strategies on WASH provisions for MHM are not prominent in WASH policies and strategies. Statements are made in the policies on general hygiene education and reproductive health as contained in states' school health policies. Specific mention is not made of provision of MHM-sensitive toilets, provision of menstrual materials, storage facilities and disposal mechanisms for used menstrual materials, among others. However, there are interventions by NGOs, WaterAid and UNICEF in these aspects. The extent to which states have been able to leverage on these opportunities reflects the state of MHM practices in the two states.

14.7 Recommendations and Development Implications

Menstrual hygiene management is yet to be fully recognized as a health issue that has significant implication for personal development, capacity building and participation of girl/women in developmental activities. For effective MHM in schools, the following should be given consideration.

- There should be dedicated policy thrusts and provisions for MHM management in schools rather than being subsumed under general hygiene education and reproductive health. The Federal Ministries of Water Resources, Education and Health should put this in place for domestication at subnational levels.
- As there are building codes and development control standards, there is need to develop WASH standards for MHM in schools with regard to provision of MHM-specific toilet facilities with respect to: quantity per category of schools based on population; the design of and compartments in such toilets (washing/bath compartment; used menstruation material storage bin, etc.), among others. The relevant physical planning agencies and ministries of education, environment and health should be involved in this. When such standards are in place, there is need to enforce compliance by Ministry of environment and physical planning agencies in charge of granting approval for development.
- Mechanisms should be in place for supply of menstrual materials/pads, soap, among others. There are NGOs supplying these to schools for the use of students. Such and more NGOs should be encouraged to sustain their gesture. However, there is need for more sustainable approach. The options include the following:
  - States could go into partnership with manufacturers of menstrual pads for bulk supply to schools, which will reduce the financial cost burden on students and their parents.
  - Building the cost of menstrual pads into school fees where school fees are paid.

– Sensitizing parents on the importance of MHM for learning, active participation of their children in school activities and implications for their future development, hence the need for them to provide menstrual materials for them.

14.8 Conclusion

Menstrual hygiene management is a health issue, which has implication for the girl/women's participation in learning and school activities and by extension personal development and future contribution to national development. The state of MHM-specific WASH facilities in each of the states examined needs improvement. There has been a weak policy response to MHM in schools and thus requires dedicated policy thrusts and strategies. The federal and state governments should take actions based on the recommended measures.

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Chapter 15
The Nexus Between Development and Early Childhood Mortality in Nigeria

Love Ugonna Umesi

15.1 Introduction

Early childhood mortality, also referred to as under-five mortality, is a critical indicator of child health, socio-economic development, quality of life, and the general health of a population group (National Population Commission Nigeria [NPC] & ICF International, 2019; Van Malderen et al., 2019; Wang et al., 2014). Under-five mortality is a focus of global action, including the Sustainable Development Goals (SGDs), because children face their highest risk of death during this period, particularly in infancy. Early childhood mortality is also linked to fertility and population growth (Preston, 2007), with Rosling (2006) arguing that improving child survivorship reduces fertility and population growth in the long run. Globally, early childhood mortality reduced by 77% between 1950 and 2015 (United Nations, 2017). While the European region had the most rapid decline in under-five mortality (93%), improvements have been more muted and patchier in Africa, where under-five mortality reduced by 71%, with noticeable variations between countries (United Nations, 2017).

The situation in Nigeria is particularly dire. While some of the least-developed African countries have seen remarkable improvements in under-five mortality, Nigeria has worsened in recent years. It now has the world's second highest under-five mortality rate (UN, 2019). The state of child health in Nigeria cannot be attributed solely to economic factors. Countries such as Rwanda, Liberia, Mali, Sierra Leone, and Niger have less economic endowment and recent civil war experiences have worsened their economic and political situations, yet they fared better than Nigeria in early childhood survival outcomes. Nigeria has a more robust economy,

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yet early childhood mortality has remained stubbornly intractable over the last decade. Unfortunately, one in every eight children in Nigeria die before their fifth birthday and more than half of those deaths are attributed to conditions that could be prevented or treated with timely access to affordable interventions such as maternal and child health care, proper handling of pregnancy-related complications, childhood vaccination against infectious diseases, and availability of basic amenities (Ezeh et al., 2015; NPC & ICF International, 2019; Ojewumi & Ojewumi, 2012).

Given the extensive research that has been carried out on maternal and child health in Nigeria, coupled with the adoption of the Millennium Development Goals (MDG) and SDGs to meet set targets, one would expect early childhood mortality in Nigeria to have reduced appreciatively in recent decades. However, the 2018 Nigeria Demographic and Health Survey (NDHS) showed that early childhood mortality in the 5 years preceding the survey increased to 132 deaths per 1000 live births, up from the 2013 NDHS figure of 128 deaths per 1000 live births (NPC & ICF International, 2019). This increase is a reversal of previous gains, where under-five mortality in Nigeria reduced from 201 to 157 deaths per 1000 live births between 2003 and 2008 (NPC & ICF International, 2004, 2009; UNICEF, 2018). The state of child health sub-nationally, as shown in Fig. 15.1, is even more worrisome given the vast differences in early childhood mortality.

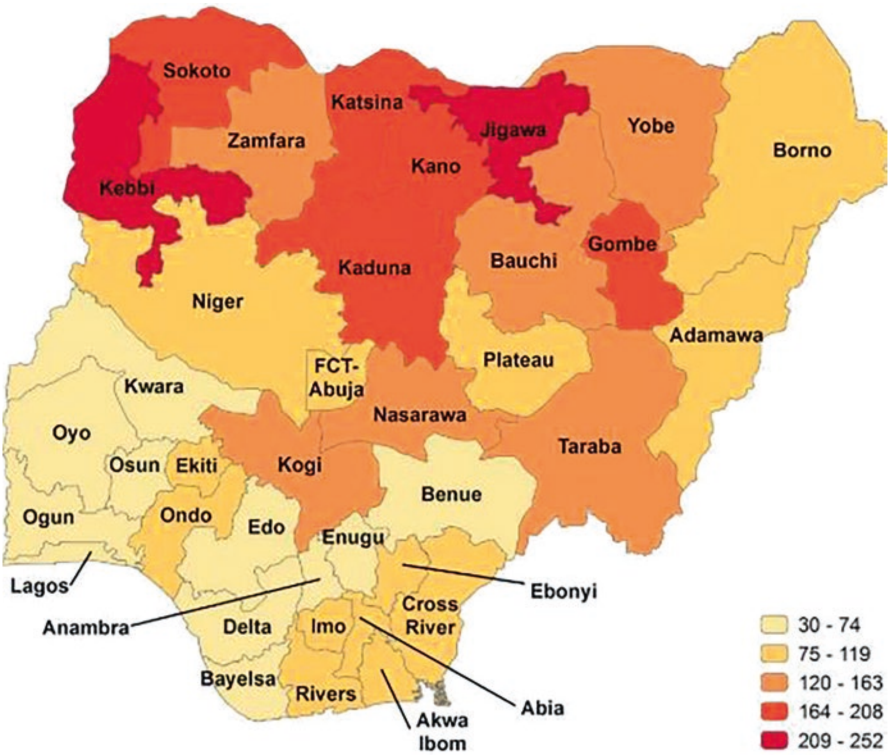

Fig. 15.1 Under-five mortality by State for the 10-year period preceding 2018 NDHS. (Source: NPC and ICF International, 2019)

Nigeria's high childhood mortality is indicative of the poor quality of health for the average Nigerian. Without an enabling environment, including access to basic health facilities and social amenities, individual health outcomes are greatly impaired, especially for children under the age of five. Evidence suggests that provision of affordable and accessible maternal and child health care by the government is a major step in reducing health inequality and helping Nigeria meet SDG target 3.2 by 2030 (Ojewumi & Ojewumi, 2012; Rutherford et al., 2010). In Rwanda, which had a very similar level of under-five mortality to Nigeria in 2000, adequate coverage of maternal and child health from the government helped it achieve a 70% reduction in under-five mortality between 2000 and 2011 (Amoroso et al., 2018).

This chapter provides an in-depth examination of the persistent inequities in under-five mortality between states in Nigeria, with a particular focus on exploring the extent to which persistently high levels of under-five mortality can be explained by the changes in key socio-economic factors over time. Examining spatial changes in early childhood mortality is crucial in adding knowledge to the literature and providing evidence-based results that will aid the government and health policymakers in implementing programmes that can address the underlying drivers of under-five mortality. The specific objectives for this study were to: (1) examine changes in under-five mortality in Nigeria from 2008 to 2018, (2) provide a fine-grained spatial analysis of relative changes in under-five mortality over the study period, and (3) determine whether there are associated variations by state in the key socio-economic development factors of interest over time.

15.2 Literature Review

While a significant number of studies have examined poor child survival outcomes in Nigeria, they are mainly focused on the geo-political zones with little attention paid to states. As such, there is a lack of understanding about how state-level factors might be associated with under-five mortality. It is known that there is a clear north-south divide in under-five mortality rates in Nigeria, with the northern regions having higher rates than the south (Adedini, 2013; Antai, 2011). In the 2018 NDHS (Table 15.1), under-five mortality over a 10-year period in Nigeria exceeded 100 deaths per 1000 live births in the North West and North East (187 and 134, respectively) but was below 100 in the southern regions (75, 73, and 63 deaths per 1000 in South East, South South and South West, respectively). Table 15.1 also shows further gaps in under-five mortality amongst Nigeria's 37 states, with intra-zonal state variation, showing that even within the same geo-political zone, some states have substantially better or worse under-five mortality rates than the zonal average. This highlights a major limitation in only undertaking analysis at the national or zonal level.

Identifying all the causes of under-five mortality is daunting given the complexity of the situation. Biological, economic, social, and environmental factors at the individual, household, and community levels play different roles, either directly or

Table 15.1 Distribution of under-five mortality rate for Nigeria by state of residence, geo-political zones and national total

Characteristic	2008 NDHS	2013 NDHS	2018 NDHS
National total (5 years preceding the survey)	**157**	**128**	**132**
National total (10 years preceding the survey)	**171**	**144**	**129**
North Central	**135**	**100**	**95**
FCT Abuja		76	75
Benue		127	59
Kogi		72	148
Kwara		63	74
Nasarawa		119	120
Niger		86	98
Plateau		130	106
North East	**222**	**160**	**134**
Adamawa		174	104
Bauchi		228	147
Borno		79	86
Gombe		186	189
Taraba		152	129
Yobe		143	152
North West	**217**	**185**	**187**
Jigawa		218	213
Kaduna		73	187
Kano		158	164
Katsina		220	188
Kebbi		194	252
Sokoto		210	197
Zamfara		256	130
South East	**153**	**131**	**75**
Abia		132	86
Anambra		87	58
Ebonyi		179	91
Enugu		111	61
Imo		133	87
South South	**138**	**91**	**73**
Akwa Ibom		79	98
Bayelsa		91	31
Cross River		104	80
Delta		93	53
Edo		71	71
Rivers		98	79
South West	**89**	**90**	**62**
Ekiti		105	95
Lagos		96	59
Ogun		93	30
Ondo		119	79
Osun		61	70
Oyo		76	64

indirectly, on the chances of survival of a newborn (Adebowale et al., 2017; Antai, 2011; Koffi et al., 2017; Sastry, 1996). This chapter focuses on key social determinants of health at the state-level such as mother's level of education, household wealth status, antenatal visits (ANC), place of delivery, and assisted delivery.

The role of individual/household socio-economic status on child health outcomes cannot be overemphasized. Studies have identified several individual/household background characteristics that act as indirect determinants of under-five mortality, including mother's education, and wealth status (Akinyemi et al., 2015; Ettarh & Kimani, 2012; Kayode et al., 2012; Koffi et al., 2017; Rutherford et al., 2010; Rutstein et al., 2009; Yaya et al., 2017). Factors at the communities, beyond the individuals and households, also form external structures that operate through these determinants. For instance, if maternal women have the right education and information and can access quality health care, some pregnancy- and childbirth-related anomalies and death can be prevented. Studies published in *The Lancet* showed that access to improved health care, quality drinking water, and improved toilet facilities are essential in improving child survival, especially for those in areas with increased exposure to infection due to their household's socio-economic status (Ezeh et al., 2017; Lilford et al., 2017). Children below the age of five have lower immunity and providing optimum conditions at this stage are crucial for enhancing their survival outcomes.

The wealth index of a household determines the resources available to a child, the type of house a child is raised in, and access to health care, thereby indirectly influencing under-five mortality (Blackstone et al., 2017; Ezeh et al., 2015; Rutherford et al., 2010). The household wealth quintile measures impact on the health of the child through a measure of the scale of social class differences in a society. Likewise, inequalities in wealth distribution and educational attainment in the household create social class separation, which impacts on access to healthcare services (Wilkinson & Pickett, 2006). In Nigeria, wealth inequalities clearly create accessibility barriers to healthcare services in ways that impact negatively on early childhood survival outcomes (Koffi et al., 2017; Ojewumi & Ojewumi, 2012).

Nigeria has high income inequality with huge gaps between the rich and the poor, where Gini coefficient worsened from 0.35 in 2004 to 0.41 in 2013 and improved slightly to 0.39 in 2016 (NBS, 2018). As shown in Table 15.2, there is disparity in headcount per poverty measure across states. The northern zones with higher poverty rates also have higher under-five mortality rates when compared with the southern zones, and states with lesser income have lower capacity to finance social services at the macrolevel. As pointed out by previous studies, the link between poverty and under-five mortality is bolstered by the poverty rate in different states in Nigeria (Ahmed, 2007; Fotso, 2006; Hong et al., 2006; Sanders & Carver, 1985).

In many developed and developing nations, an increase in GDP is usually followed by investment in education, healthcare and social services, resulting in improved child survival (Rosling, 2006). This is not the case in Nigeria. Instead, the country has experienced persistently high under-five mortality rates despite a steady rise in GDP from the 1990s as shown in Fig. 15.2. Studies have shown that mortality

Table 15.2 Headcount per capita poverty measure (%) for Nigeria

	2003–04	2009–10
National	**64.2**	**62.6**
Rural	73.4	69.0
Urban	52.2	51.2
North Central		
Benue	64.7	73.6
FCT (Abuja)	53.3	45.5
Kogi	91.8	67.4
Kwara	87.8	72.1
Nasarawa	66.1	78.4
Niger	64.4	51.0
Plateau	68.5	72.4
North East		
Adamawa	76.6	77.8
Bauchi	87.8	84.0
Borno	59.8	60.6
Gombe	73.1	81.6
Taraba	60.5	68.3
Yobe	88.0	81.7
North West		
Jigawa	95.3	88.5
Kaduna	54.2	64.0
Kano	59.4	70.4
Katsina	72.9	77.6
Kebbi	90.8	72.5
Sokoto	75.2	86.1
Zamfara	84.0	67.5
South East		
Abia	40.9	50.2
Anambra	41.4	53.7
Ebonyi	63.2	82.9
Enugu	50.2	60.6
Imo	46.7	39.4
South South		
Akwa Ibom	56.8	51.0
Bayelsa	40.0	44.0
Cross River	67.0	60.4
Delta	70.6	53.8
Edo	53.6	64.1
Rivers	56.7	47.2
South West		
Ekiti	60.4	55.9
Lagos	69.4	40.3
Ogun	49.9	57.6
Ondo	62.8	57.7
Osun	44.6	37.5
Oyo	38.0	50.8

Source: NBS (2010)

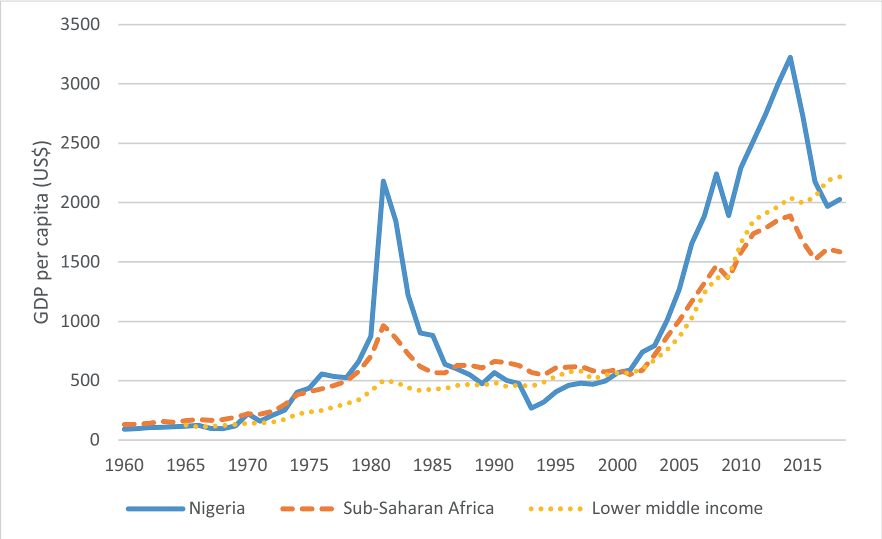

Fig. 15.2 Nigeria's GDP per capita with aggregates. (Source: World Bank, 2019)

decline, especially in sub-Saharan Africa, can be largely sustained through improvement in standards of living and public health measures such as clean drinking water, sanitation, and public health education (Wilmoth, 2003). However, Rosling (2006) cautioned that improved health outcomes do not happen automatically, but rather are products of governmental development policies in social, educational, and health services. This implies that broad socio-economic development in Nigeria, and Africa at large, can be sustained by improvements in child health. With more than half of its population aged 15 to 65 years, Nigeria has the potential to witness accelerated development and capitalize on its 'demographic dividend' (Bloom et al., 2003). However, this requires that the government make investments in education and heath a priority, while providing an enabling environment for continuous economic growth (UN-DESA, 2019). This can be done through provision of quality and affordable education up to secondary level, provision of health services and basic social infrastructure, as well as creation of more job opportunities and support for private enterprise.

The conceptualization of this chapter is from the underlying premise that socio-economic factors strongly influence variations in under-five mortality. This influence occurs indirectly. Variations in socio-economic development at the state-level enable inequality in the socio-economic status of individuals and households. Variations in individual and household socio-economic status play a central role in shaping the proximate determinants of mortality amongst under-five children. Clearly, inequalities in place of residence (rural, urban), and between and within states, are associated with child survival outcomes in Nigeria. Possible explanations are poor socioeconomic factors within the state and inability of households with low income to pay for health services in the absence of universal health care, especially for maternal women and children below the age of five.

15.3 Data and Methods

The data used in this study is sourced from the 2008, 2013 and 2018 NDHS, which are the three most recent ones carried out by the National Population Commission, Nigeria. ICF International provided technical assistance for the surveys through the DHS Program, with funding from United States Agency for International Development (USAID) (National Population Commission (NPC) Nigeria & ICF International, 2009, 2014, 2019). NDHS is a nationally representative household survey designed to provide population and health data from regular households at the national, geo-political and state levels.

For administrative purposes, Nigeria is divided into 37 states (36 states plus the Federal Capital Territory), with the states further divided into 774 Local Government Areas (LGAs), and LGAs into localities. From the localities, smaller units called Census Enumeration Areas (EAs) were created during the 2006 Population and Housing Census. The 2008, 2013 and 2018 NDHS primary sampling units (PSUs), referred to as clusters, are defined based on the 2006 EA census frame. The sample selection for the surveys involved a two-stage stratified sample design, where the 37 states were separated into urban and rural (based on the 20,000-population threshold for urban area) making a total of 74 sampling strata, from where samples were selected using a two-stage selection per stratum. The number of households was distributed proportionately amongst urban and rural areas in each state during each survey, while interviews were completed from women aged 15–49 years who were either permanent residents or visitors who spent the night before the survey in the selected households in 2008, 2013 and 2018 NDHS, respectively (National Population Commission (NPC) Nigeria & ICF International, 2009, 2014, 2019). Further information on questionnaire design, sample design, data collection, analysis and other implementation strategies of the Nigeria Demographic and Health Survey can be found in the final reports (National Population Commission (NPC) Nigeria & ICF International, 2009, 2014, 2019).

15.3.1 Analytical Strategy

The analyses examine trend and patterns of under-five mortality in Nigeria from 2008 to 2018 and compare them with changes in the key study variables (mother's level of educational attainment, household wealth status, antenatal visits, place of delivery and assisted delivery), to ascertain if these factors contributed to spatial variations in under-five mortality in Nigeria. Women aged 15–49 years with at least a live birth within the 5 years preceding each survey are included in the analysis, with the unit of analysis being children born in the 5 years preceding the surveys. The 5-year reference period is necessary to limit recall bias to explore recent events and provide a more accurate information. Under-five mortality or early childhood mortality is the probability of a child dying between birth and fifth birthday if subject to age-specific mortality rates at the time of birth (Adedini, 2014; NPC & ICF International, 2019). Respondents were asked if they had children who were born alive but later died, and the age at death. Age at death is used to estimate early childhood mortality. As children die at different rates during the childhood period, with the highest mortality during the first year of life, to provide more robust analyses, the outcome variable is disaggregated into two stages of childhood development.

1. Infant death: Number of deaths before the first birthday
2. Child death: Number of deaths between the first and fifth birthday

15.4 Results

This section focuses on results from the trends and patterns of under-five deaths and study variables in Nigeria, paying particular attention to inter-regional, intra-regional and inter-state variations. Prior studies of early childhood mortality in Nigeria have shown that the risk of death is highest in the first year of life, largely due to high neonatal deaths in the first 27 days (Ekwochi et al., 2015; Fetuga et al., 2007). Consistent with these findings, Fig. 15.3 shows the risk of early childhood mortality in Nigeria is higher in infancy, both nationally and sub-nationally. Throughout the focal period, infant (0–11 months) mortality was almost double that of childhood mortality (12–59 months). As reported in NDHS 2013, 70% of under-five deaths occurred at infancy. Also, there was a marked increase in the proportion of deaths that occurred at infancy from 2008 to 2013, while deaths in childhood reduced in the same period. Infant deaths reduced marginally from 2013 to 2018, with a contrasting increase in child deaths in the same period. Remarkably, the distribution of death for these indicators remained almost static from 2008 to 2018 at the national level. Whatever improvement (in the case of childhood mortality) or

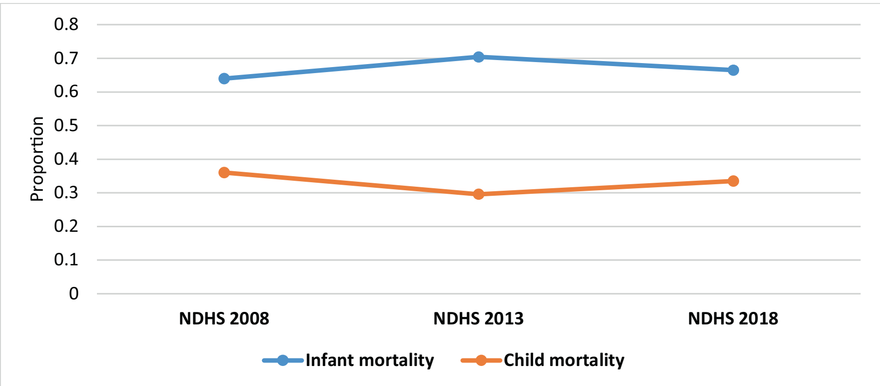

Fig. 15.3 Proportion of infant and child deaths amongst under-five deaths in Nigeria from 2008 to 2018

loss (in the case of infant mortality) was made in 2013 became almost insignificant in 2018. Infant deaths increased from 64% at the onset of the study period in 2008 to 66% at the end of the period in 2018, while child deaths reduced from 36% in 2008 to 33% in 2018. Figure 15.3 clearly highlights the little progress made in improving child survival over more than a decade in Nigeria.

Subsequent analyses focus on vital aspects of this chapter – levels, trends and differentials of infant and child deaths by geo-political zones and states. Findings on under-five mortality at the sub-national level are discussed in the light of the key study variables observed in different geo-political zones and states. This level of analysis is important to raise awareness about the situation at the zonal and state levels and shed light on how they relate to sub-national disparities in early childhood survival.

15.4.1 Levels, Trends and Differentials in Under-Five Mortality by Geo-political Zones

There exist vast differences in early childhood survival outcomes between and within the six geo-political zones that cannot be ignored. Exploring these zonal differences helps in identifying unique background characteristics within the zones that might be associated with under-five mortality, thus providing a more strategic view on under-five mortality in Nigeria. Inter-zonal differences in maternal education, religion and cultural practices have been identified in past studies as possible drivers of these differences (Adedini et al., 2015a, b). Disaggregation of infant and child deaths by geo-political zones as depicted in Figs. 15.4 and 15.5 not only reveals inter-zonal differences but also a clear north-south divide. Consistent with other studies, under-five mortality rates are substantially higher in the northern geo-political zones than in the southern parts (Adebowale et al., 2012; Adedini et al., 2015a). The figures illustrate that the northern regions reported increased infant and child deaths from 2013 to 2018, except for child deaths in North East from 2013 to 2018 as shown in Fig. 15.5. This is an indication that these regions contributed significantly to the increase in under-five mortality observed at the national level from 2013 to 2018. In contrast, early childhood deaths in the three southern regions declined steadily throughout the study period.

Although under-five mortality was highest in the North West in all three survey points, the increase in 2018 is particularly noteworthy because under-five mortality had declined significantly in the previous period. A possible explanation for this reversal could be the increase in internal migration from the neighbouring North East region, due to increasing insecurity in the region because of activities of the terrorist group, Boko Haram. These terrorists have killed thousands of people, displaced or captured hundreds of thousands more, destroyed social and health infrastructures and paralysed economic activities in the North East (Adamu et al., 2021; Ager et al., 2015; Dunn, 2018). It is possible that the activities of the terrorist group

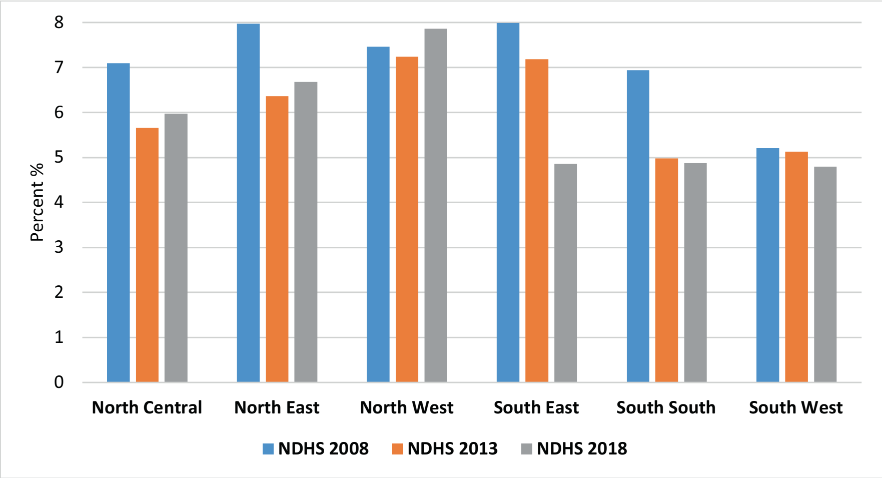

Fig. 15.4 Percentage of infant (0–11 months) deaths by geo-political zones, Nigeria 2008–2018

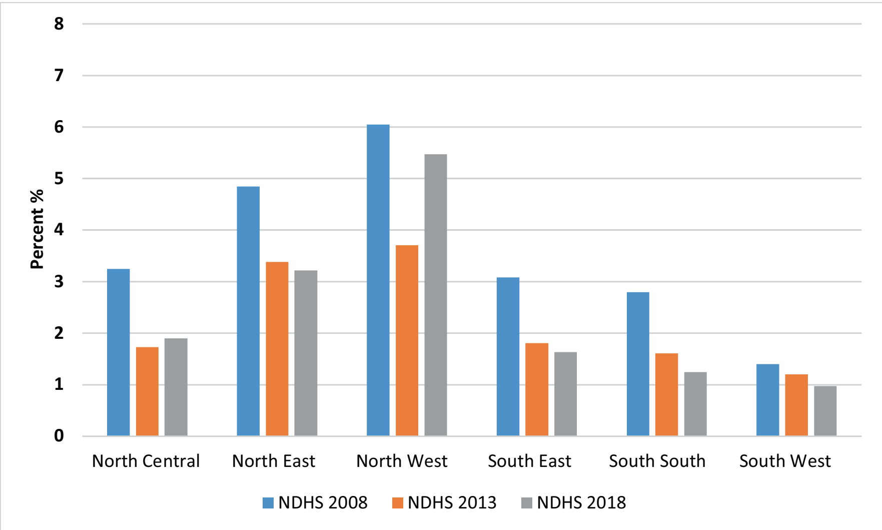

Fig. 15.5 Percentage of child (12–59 months) deaths by geo-political zones, Nigeria 2008–2018

may have created an existing health burden on the children, coupled with lack of health care and challenges with being displaced, thereby leading to their death on arrival at their new destinations.

The geo-political zone comparisons also reveal notable progress in the South East. Infant deaths were almost at par with the North East in 2008 and higher than North Central in 2008 and 2013, but it declined slowly in the zone in 2013 and then sharply in 2018. However, South East still had the highest proportion of child deaths

Table 15.3 Trends and differentials in infant deaths by geo-political zones, Nigeria 2008–2018

				% Change		
Infant deaths	NDHS 2008 (%)	NDHS 2013 (%)	NDHS 2018 (%)	(2008–2013)	(2013–2018)	(2008–2018)
Geo-political zone						
North Central	7.1	5.7	6.0	−20.4	5.7	−15.8
North East	8.0	6.4	6.7	−20.2	4.9	−16.2
North West	7.5	7.2	7.9	−2.9	8.6	5.4
South East	8.0	7.2	4.9	−10.1	−32.4	−39.2
South South	6.9	5.0	4.9	−28.2	−2.2	−29.8
South West	5.2	5.1	4.8	−1.5	−6.4	−7.8

Table 15.4 Trends and differentials in child deaths by geo-political zones, Nigeria 2008–2018

				% Change		
Child deaths	NDHS 2008 (%)	NDHS 2013 (%)	NDHS 2018 (%)	(2008–2013)	(2013–2018)	(2008–2018)
Geo-political zone						
North Central	3.2	1.7	1.9	−46.6	9.8	−41.4
North East	4.8	3.4	3.2	−30.2	−4.8	−33.6
North West	6.0	3.7	5.5	−38.6	47.5	−9.5
South East	3.1	1.8	1.6	−41.4	−9.6	−47.0
South South	2.8	1.6	1.2	−42.4	−22.7	−55.5
South West	1.4	1.2	1.0	−13.9	−18.8	−30.1

in the southern region at 1.9%. All zones made clear progress in reducing under-five deaths from 2008 to 2013, although the trend was more muted in the South West.

Tables 15.3 and 15.4 further present Chi-square (chi-2) tested results and percentage changes in under-five deaths by geo-political zones. The results showed significant relationships between under-five deaths and geo-political zones throughout the study period, suggesting that factors within the geo-political zones are relevant in studying under-five mortality in Nigeria. In assessing the percentage change in early childhood mortality over time, Table 15.3 shows that the overall highest reduction in infant deaths was reported in the South East. In contrast, the North West had an increase of 5.4% between 2008 and 2018. Table 15.4 shows that South South made the most overall improvement with more than 50% decrease in child deaths, while North West made the least. Generally, there was more progress made in reducing child deaths than infant deaths.

15.4.2 Levels, Trends and Differentials in Under-Five Mortality by States

State-level variations and intra-zonal differences amongst states in the same geo-political zone are important to highlight. One of the key contributions of this research is not only to explore variations between zones, but also to highlight variations in under-five mortality amongst states in the same geo-political zones. As other scholars have shown, there are state-level differences across a wide range of human development outcomes that do not map neatly onto geo-political zones (Adedokun et al., 2017; Ayoade, 2020; Olorunsaiye & Degge, 2016). Tables 15.5 and 15.6 present more granular spatial analysis of levels, trends and differentials in infant and child mortality in Nigeria. Percentage changes in under-five deaths pinpoint critical lows and highs for each state across the period, by showing the size of change in under-five deaths. These patterns help in identifying states where current programmes need to be sustained and those that require urgent attention.

Table 15.5 Trends and differentials in infant deaths by states, Nigeria 2008–2018

				% Change		
Infant deaths	NDHS 2008 (%)	NDHS 2013 (%)	NDHS 2018 (%)	(2008–2013)	(2013–2018)	(2008–2018)
State						
North Central						
Benue	9.4	6.8	3.7	−27.2	−46.7	−61.2
FCT (Abuja)	6.3	5.2	4.3	−17.4	−18.6	−32.8
Kogi	5.5	3.8	8.2	−29.9	112.8	49.2
Kwara	3.3	5.3	5.8	63.1	9.9	79.2
Nasarawa	6.2	6.0	7.5	−2.9	25.3	21.7
Niger	7.9	4.9	6.0	−38.0	21.9	−24.4
Plateau	7.4	7.0	7.4	−5.1	4.8	−0.5
North East						
Adamawa	10.1	7.8	7.2	−22.3	−8.8	−29.1
Bauchi	7.9	8.1	6.5	2.1	−19.4	−17.7
Borno	8.8	2.7	4.5	−69.6	69.3	−48.6
Gombe	6.2	6.9	9.6	10.9	39.3	54.5
Taraba	7.9	7.4	6.0	−6.6	−18.6	−23.9
Yobe	5.7	5.9	7.4	2.6	26.3	29.6
North West						
Jigawa	5.5	8.6	7.9	56.7	−7.8	44.5
Kaduna	7.0	3.7	11.1	−48.0	202.3	57.1
Kano	9.3	6.8	6.2	−27.5	−8.2	−33.4
Katsina	6.6	5.0	5.7	−24.8	14.6	−13.8

(continued)

Table 15.5 (continued)

				% Change		
Infant deaths	NDHS 2008 (%)	NDHS 2013 (%)	NDHS 2018 (%)	(2008–2013)	(2013–2018)	(2008–2018)
Kebbi	6.2	8.8	10.4	42.4	18.1	68.1
Sokoto	8.4	7.8	8.4	−7.2	7.7	0.0
Zamfara	6.7	10.8	6.6	60.4	−38.8	−1.8
South East						
Abia	8.3	7.7	6.7	−6.6	−13.6	−19.3
Anambra	5.0	6.2	3.1	22.4	−50.4	−39.3
Ebonyi	9.3	8.4	4.6	−9.4	−45.2	−50.3
Enugu	8.2	6.4	5.2	−21.7	−18.2	−36.0
Imo	10.5	7.2	6.6	−31.5	−8.8	−37.6
South South						
Akwa Ibom	6.7	5.6	6.8	−15.8	21.0	1.9
Bayelsa	9.8	4.3	2.3	−55.9	−45.7	−76.0
Cross River	4.5	4.1	5.1	−8.9	25.3	14.2
Delta	8.3	5.9	3.5	−29.0	−40.3	−57.6
Edo	7.4	2.9	5.5	−60.3	87.9	−25.3
Rivers	6.2	5.8	4.8	−6.0	−17.1	−22.1
South West						
Ekiti	5.0	5.2	7.4	5.1	40.8	48.0
Lagos	5.1	5.8	5.7	12.9	−1.0	11.7
Ogun	7.0	5.3	1.6	−24.3	−70.0	−77.3
Ondo	4.3	6.4	4.3	49.2	−32.7	0.3
Osun	3.0	3.7	5.6	20.9	53.4	85.4
Oyo	5.7	4.2	4.2	−26.6	−0.6	−27.1

While analysis at the regional level provides some insight into the sub-national dynamics, a closer look inside regions shows noticeable differences in under-five mortality with visible peaks and troughs across states, emphasizing the need for sub-national analysis at the state- level. Spatial analysis ensures accountability at the state levels, since provision of primary health care is largely managed by the state and local governments (Adedini, 2013; Ogbuoji & Yamey, 2019). Chi-2 tested results in Tables 15.5 and 15.6 indicate that structures at the state- level are significantly associated with under-five mortality in Nigeria. When the states were ranked from the least to the highest percentage of infant deaths, Kaduna went from being the 21st state in 2008 to the state with the highest infant deaths in 2018 with 11%, even worse than Imo's fig. (10.54%) in 2008, when it had the highest infant deaths. In contrast, Ogun progressed from being the 20th state in 2008, just one step ahead of Kaduna, to recording the lowest rate of 1.6% in 2018. This result highlights the vast disparity in infant deaths amongst states.

In the North Central, Benue and the FCT made the most progress, while Kwara made the least. Results also show that Kogi went from 30% mid-point decrease to

Table 15.6 Trends and differentials in child deaths by states, Nigeria 2008–2018

				% Change		
Child deaths	NDHS 2008 (%)	NDHS 2013 (%)	NDHS 2018 (%)	(2008–2013)	(2013–2018)	(2008–2018)
State						
North Central						
Benue	2.0	2.3	0.6	15.4	−73.7	−69.7
FCT (Abuja)	1.8	1.0	1.6	−42.8	53.2	−12.4
Kogi	3.0	1.8	4.1	−40.7	130.8	36.8
Kwara	1.1	1.4	0.9	31.1	−34.9	−14.6
Nasarawa	2.2	2.3	2.1	4.3	−9.4	−5.5
Niger	6.7	1.6	2.0	−76.4	30.1	−69.3
Plateau	2.5	1.0	2.7	−59.6	170.0	9.0
North East						
Adamawa	5.0	1.9	2.0	−61.7	6.1	−59.4
Bauchi	5.7	5.1	3.9	−11.6	−22.9	−31.9
Borno	4.1	2.2	1.9	−46.9	−9.9	−52.1
Gombe	4.8	4.1	4.1	−14.3	−1.8	−15.8
Taraba	3.9	2.3	4.0	−39.8	70.4	2.6
Yobe	5.0	3.8	3.4	−24.8	−9.0	−31.6
North West						
Jigawa	6.8	4.8	6.8	−28.8	41.2	0.6
Kaduna	4.3	0.8	4.1	−81.1	395.6	−6.2
Kano	7.0	3.4	5.6	−51.4	64.1	−20.3
Katsina	6.1	4.1	6.1	−32.6	50.3	1.3
Kebbi	3.7	3.4	7.7	−9.8	128.4	106.0
Sokoto	7.5	4.8	4.5	−35.8	−7.8	−40.8
Zamfara	5.1	4.8	3.7	−4.5	−23.7	−27.1
South East						
Abia	3.1	1.0	0.6	−68.7	−38.5	−80.7
Anambra	4.2	1.2	1.3	−71.6	10.5	−68.6
Ebonyi	2.8	3.0	2.2	5.3	−26.0	−22.2
Enugu	2.0	1.5	1.2	−23.5	−22.2	−40.5
Imo	2.5	1.7	2.4	−33.2	41.5	−5.5
South South						
Akwa Ibom	4.6	1.6	1.2	−65.1	−24.5	−73.6
Bayelsa	2.9	1.4	0.6	−52.0	−57.4	−79.6
Cross River	1.7	2.1	0.4	19.2	−80.2	−76.4
Delta	2.2	1.4	1.2	−36.1	−15.0	−45.7
Edo	2.1	1.5	1.7	−30.6	13.9	−20.9
Rivers	3.1	1.6	1.5	−48.8	−2.2	−50.0
South West						
Ekiti	2.6	0.6	2.4	−75.2	279.0	−6.0

(continued)

Table 15.6 (continued)

Child deaths	NDHS 2008 (%)	NDHS 2013 (%)	NDHS 2018 (%)	% Change (2008–2013)	(2013–2018)	(2008–2018)
Lagos	1.2	0.6	0.5	−50.8	−12.4	−56.9
Ogun	1.2	1.1	0.5	−5.8	−51.1	−53.9
Ondo	2.5	2.2	2.2	−14.5	2.5	−12.4
Osun	1.2	0.4	0.6	−68.9	62.3	−49.5
Oyo	0.9	1.9	1.1	118.6	−41.1	28.7

more than 100% increase in infant deaths from 2013 to 2018. Amongst the North East states, Adamawa and Borno recorded marked reductions in infant deaths from 2008 to 2013, which was visible at the regional level, while the other states in the region made no visible progress at the time. Nevertheless, Borno and two other states in the region recorded an increase in infant deaths from 2013. What little progress had been made in the North West from 2008 to 2013 was cancelled out by increase in infant deaths from 2013 to 2018 in more than half of the North West states. To put this in context, Kaduna went from a 48% reduction in infant deaths from 2008 to 2013, to more than 200% increase between 2013 and 2018.

Moving on to the southern states, infant mortality rates for all the states in the South East reduced between 2008 and 2018, reinforcing what was seen at the regional level, especially the progress reported in Imo, which had the highest infant mortality rate in 2008. Only Anambra reported an increase in infant deaths from 2008 to 2013, which was subsequently followed by a 50% reduction between 2013 and 2018. In the South South, improvements seen earlier at the zonal level from 2008 to 2013 can be attributed to the individual reductions in infant deaths seen in the states in Table 15.5, especially those of Bayelsa and Edo. However, Edo's progress was not sustained, as infant mortality deteriorated between 2013 and 2018. Finally, in the South West, Ogun with more than 70% decrease recorded the most progress at reducing infant deaths, while Osun with more than 80% increase recorded the least. Intra-state dynamics during the study period culminated in the muted progress seen earlier at the South West zonal level.

Child mortality analysis by state in Table 15.6 consolidated the pattern seen in infant mortality results, where states in North East and North West reported the highest rates. When ranked from the least to the highest child deaths as well, Cross River went from being sixth in 2008 to the state with the least reported child deaths in 2018 at 0.4%, whereas Kebbi went from the 22nd position amongst 37 states in 2008 to reporting the highest rate of child death (7.7%) in 2018.

In North Central, Benue and Niger made the most progress, while Kogi made the least. It can also be seen that Kogi and Plateau had more than 100% increase in child deaths between 2013 and 2018. Only Taraba recorded an overall increase in child deaths amongst states in the North East, with Adamawa and Borno also recording the highest decrease. The rapid fall and rise in child deaths observed in the North West earlier in Fig. 15.5 is clearer from intra-zonal and intra-state patterns shown in

Table 15.6. All the North Western states made progress between 2008 and 2013 but dropped from 2013 to 2018 with the exceptions of Sokoto and Zamfara. The table further shows from 2008 results that the North West had such poor childhood survival rate that even Zamfara with the lowest percentage in the zone was still higher than childhood survival results from the southern zones.

Child mortality rates for all the states in the South East reduced between 2008 and 2018. Abia with 81% reductions in deaths made the most progress in the zone, while Imo with 5% reductions made the least. South South states also progressed substantially, with all the states recording overall reductions in child deaths. Akwa Ibom made the most progress, while Edo with 20% reductions in child deaths made the least. Going further to the South West, only Oyo state with a 29% increase in child deaths did not report reductions in child deaths throughout the focal period. Surprisingly, Ekiti went from reporting a 75% decrease in child deaths between 2008 and 2013 to more than 200% increase between 2013 and 2018.

Overall analysis of under-five deaths in Nigeria indicates that in over a decade, most states in the country are still around the same place. These findings confirm that we have not progressed to the point where we can say as a country that we have made a positive shift in improving under-five mortality that can be escalated to the state level. To this end, strategic actions are needed by government at all levels, if Nigeria is to make progress in improving early childhood survival.

Having examined spatial variations in under-five mortality over a decade, this chapter proceeds to explore the spatial distribution of key variables over the same period. Sub-national distribution of the study measures, showing different dynamics across the country and their changes over time from 2008 to 2018, provides an enhanced understanding of the trend and rate of socio-economic development across the country. This level of information, often hidden in studies that only disaggregate to the regional level, would help programmes and research on the persistently high sub-national inequality in under-five mortality in Nigeria.

15.4.3 Summary of Trends in Maternal Educational Attainment

Results on mother's education amongst children born within 5 years of the surveys show higher rates of illiteracy amongst women in the northern region during the period under study. Figure 15.6 indicates a reduction in the proportion of children born to women with no formal education across all the regions with an attendant increase in secondary and higher levels educational attainment. But North West consistently had the highest levels of no education across the period at 78, 77 and 73% in 2008, 2013 and 2018, respectively, while South East had the lowest at 3% in 2018. Most recent result in 2018 reveals that 20% of the children in the South West were born to women with higher education, which was the highest percentage of those with higher education in the country, in contrast to only 3% in the North West.

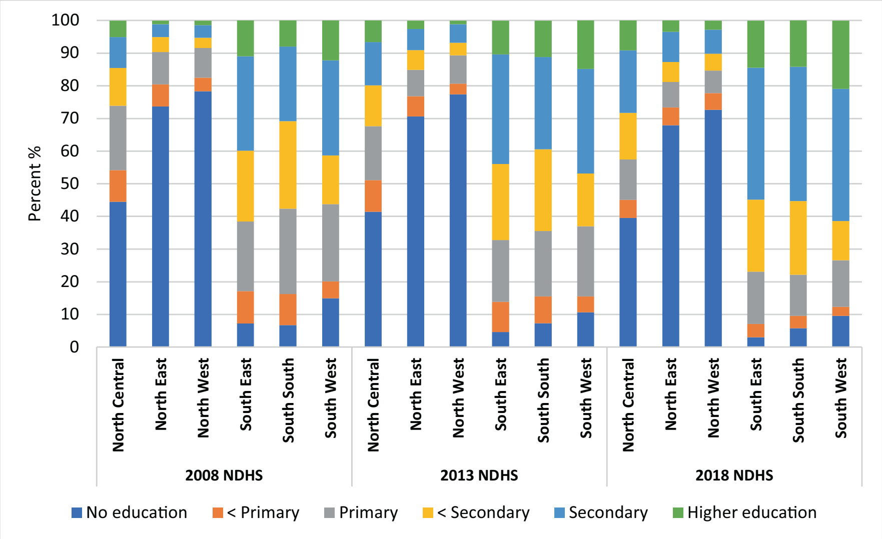

Fig. 15.6 Distribution of children born in the 5 years preceding each survey by maternal educational attainment and geo-political zone, Nigeria 2008–2018

State analysis across the period as shown in Figs. 15.7, 15.8 and 15.9 further highlights the contributions of the different states to changes in educational attainment seen at the regional level. There was a high concentration of children born to women without formal education in the northern states. Sokoto state (North West) at 93% had the highest proportion of children born to women with no education in 2018, while Imo state (South East) with less than 1% had the lowest. Generally, Lagos state (South West) with 30% had the highest proportion of children born to women with higher education. Improvements in educational attainment could be seen from the figures, as the proportion of children born to women with secondary or higher education improved across the board from 2008 to 2018.

15.4.4 Summary of Trends in Household Wealth Quintile

As illustrated in Fig. 15.10, the proportion of children born into households in the highest wealth quintile in the six geo-political zones increased over time, with an associated reduction in children born in households in the lowest quintile. The only exception was in South East, where there was a marginal 1% increase in the proportion of children in the poorest households from 2008 to 2018. Higher wealth inequality was evident in the North East and North West zones in 2018 – less than 20% of the children belonged to households in the two upper socio-economic status, in contrast with more than 70% in the South West. Similarly, less than 10% of the

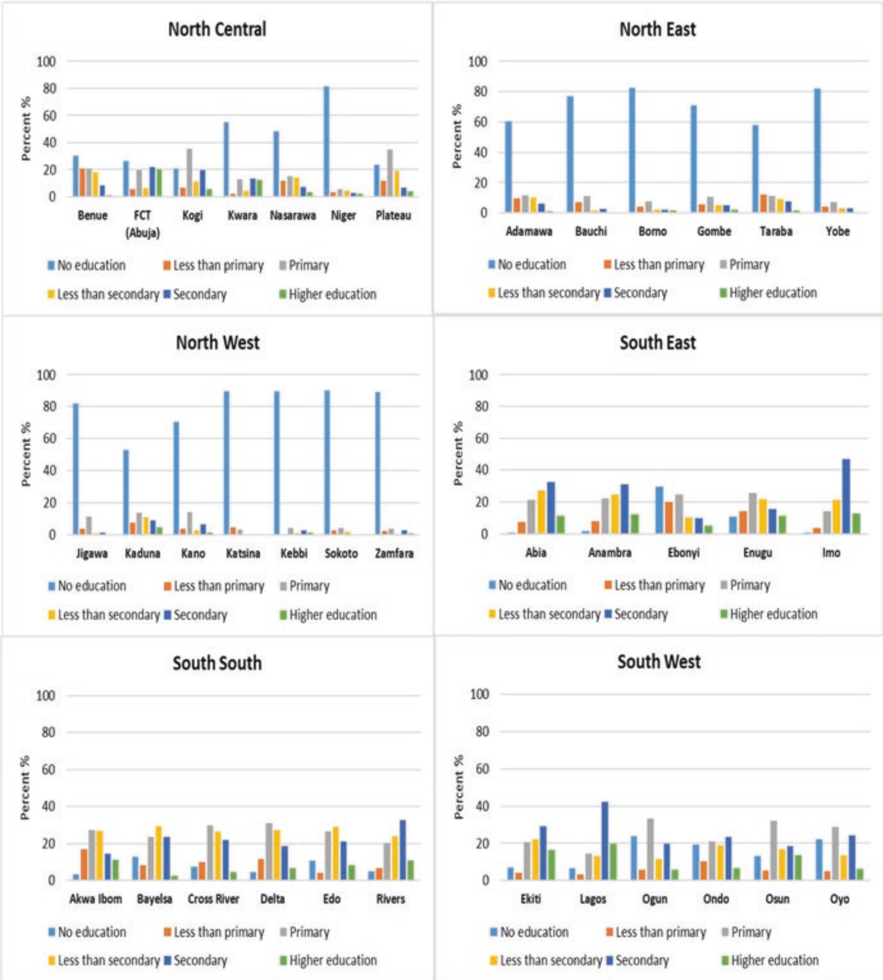

Fig. 15.7 Distribution of children born in the 5 years preceding 2008 NDHS by mother's educational attainment and state, Nigeria 2008

children in North East and North West were from households in the highest wealth group, as against 32 and 47% in South South and South West, respectively.

Analysis by state shown in Figs. 15.11, 15.12 and 15.13 illustrates that while more children in the southern states escaped poverty over time, a higher proportion of those in the northern states were still trapped in the poor class. As of 2018, more than half of the children in Jigawa, Sokoto and Zamfara states, all in the North West, were from households in the lowest socio-economic status, in sharp contrast to Abia (South East) and Lagos (South West) with 54 and 76% of their children, respectively, in the highest socio-economic status. Results also reveal a more even spread of wealth in the southern states than in the northern states. The FCT (Abuja) in the

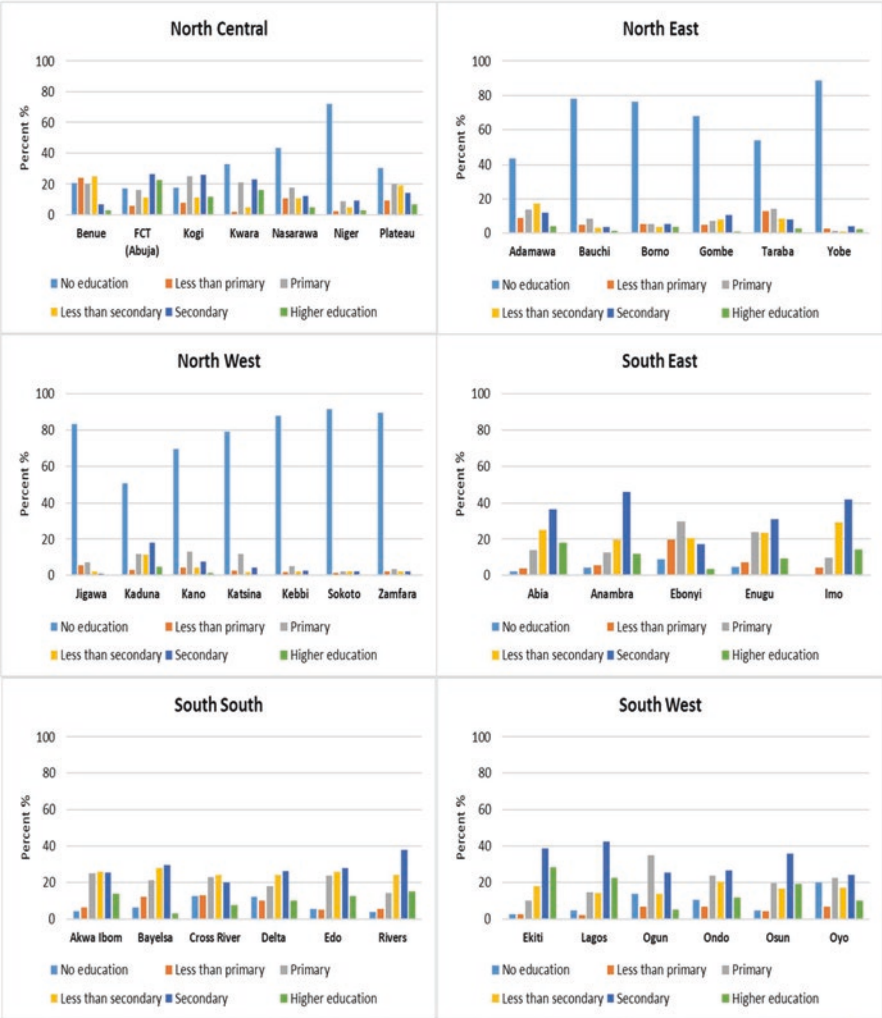

Fig. 15.8 Distribution of children born in the 5 years preceding 2013 NDHS by mother's educational attainment and state, Nigeria 2013

North Central recorded the highest proportion of children (39%) in the highest wealth quintile amongst the northern states, a reflection of its socio-economic pull because of its status as the country's seat of power. Similarly, Lagos being the commercial nerve-centre of Nigeria also trumped the rest of the southern states, and the country at large, with the highest proportion of children belonging to households in the highest wealth quintile.

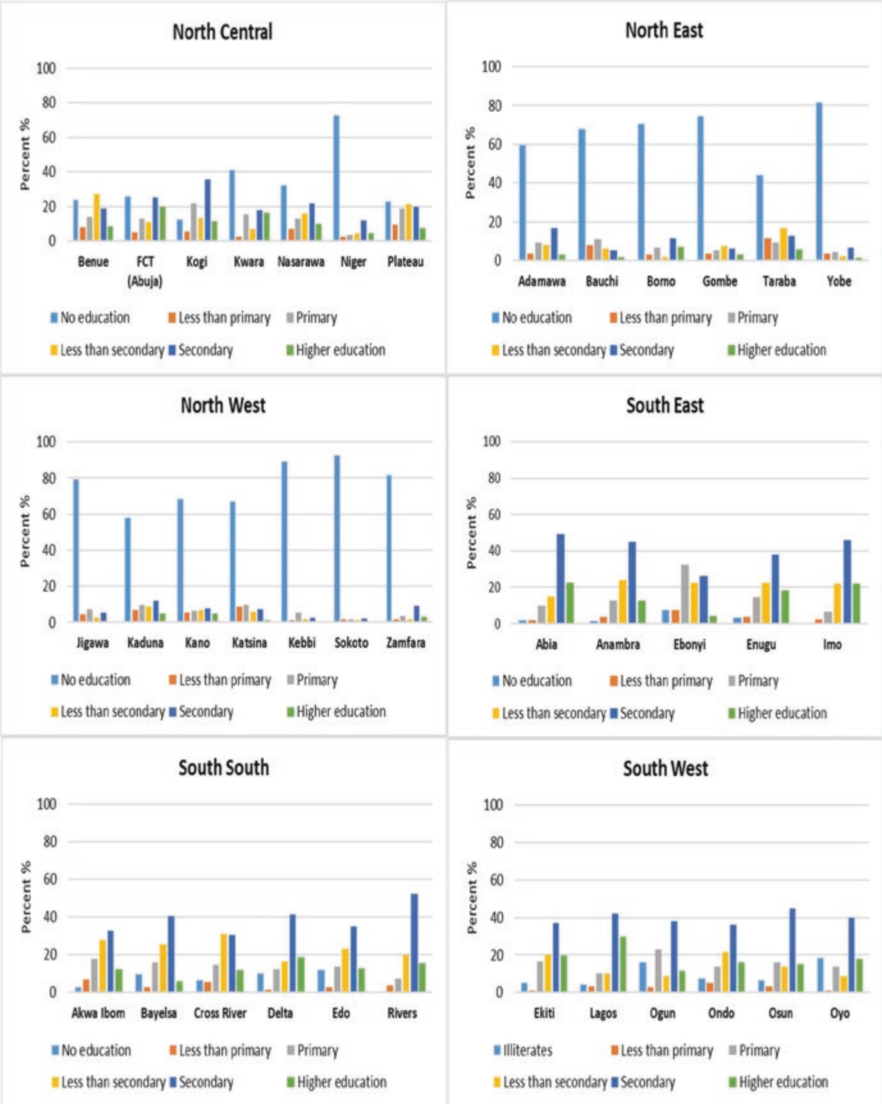

Fig. 15.9 Distribution of children born in the 5 years preceding 2018 NDHS by mother's educational attainment and state, Nigeria 2018

15.4.5 Summary of Trends in Maternal Care

This section presents results on components of maternal care leading up to pregnancy, with focus on antenatal care visits, place of delivery and access to a professional birth attendant during delivery. Results on ANC attendance during pregnancy showed clear variations across geo-political zones and states. Findings by

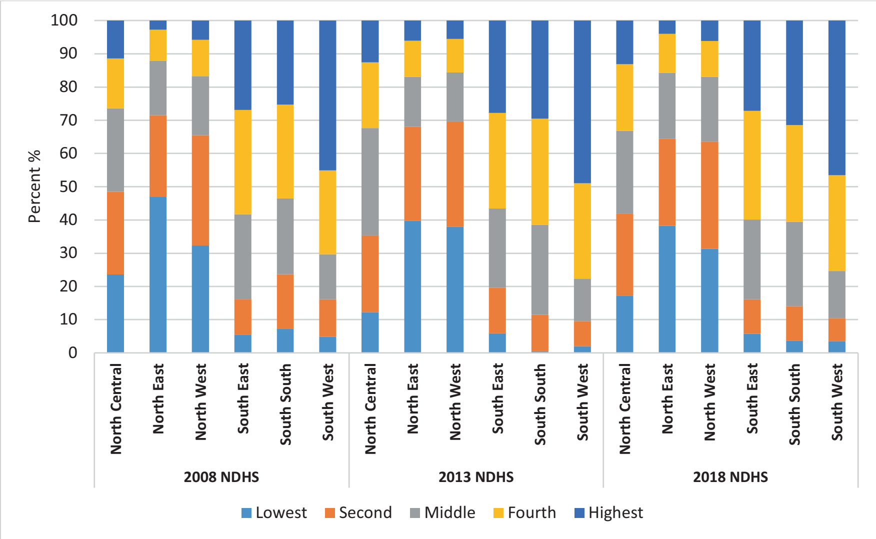

Fig. 15.10 Distribution of children born in the 5 years preceding each survey by household wealth and geo-political zone, Nigeria 2008–2018

geo-political zones in Fig. 15.14 indicate that the South West with 84% in 2018 reported the highest proportion of children whose mothers attended ANC up to the recommended four visits during pregnancy, while the North West with 42% reported the lowest. Generally, there were reductions in the proportion of children born to maternal women who did not attend ANC during pregnancy throughout the study period. Nevertheless, more than 25% of the children in the northern zones still had mothers who did not attend ANC.

State results in Figs. 15.15, 15.16 and 15.17 underscore what was shown at the zonal levels with regards to improvement in the proportion of children born to women who received at least four antenatal cares. However, there still exist a high proportion of children whose mothers did not receive antenatal care, with Zamfara and Sokoto (in the North West) as high as 64 and 53%, respectively, in 2018. Osun state (South West) at 96% had the highest proportion of children whose mothers attended ANC at least four times, while Kebbi (North West) with 27% had the lowest.

Moving on to place of delivery. Results by geo-political zones shown in Fig. 15.18 suggest that a high proportion of the children were still delivered at home. It is evident that home deliveries expose maternal women and infants to higher risks of mortality and should be discouraged (Greenwell & Winner, 2014). The North West had the highest rates of home deliveries throughout the study period from 91 to 84%, while South East and South West with 17% had lowest proportions of home deliveries. While other geo-political zones reported more deliveries at the government health facilities, the South East reported more deliveries at the private facilities.

State results in Figs. 15.19, 15.20 and 15.21 further accentuate what was seen at the regional level. The 2018 NDHS results suggest that more than 80% of the

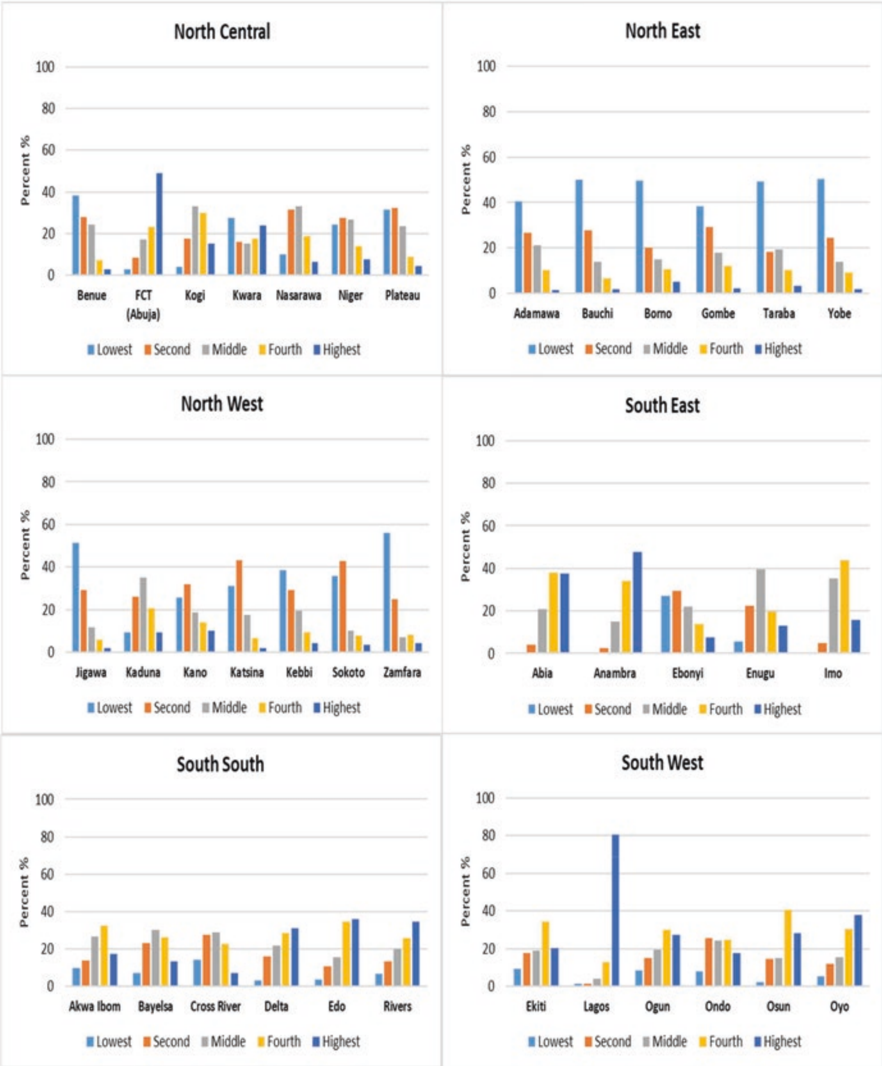

Fig. 15.11 Distribution of children born in the 5 years preceding 2008 NDHS by household wealth and state, Nigeria 2008

children in the North West states were delivered at home. The highest proportion of home deliveries was Sokoto's (North West) 92%, while Imo's (South East) 5% was the lowest proportion of home deliveries in 2018. Amongst the South East states, Ebonyi had a marked high proportion of home deliveries. Remarkably, there is a growing demand for private health facilities, especially in the southern parts of the country, with Imo State (South East) reporting in 2018 that about three-quarters of its deliveries took place in private health facilities. Amongst the southern states,

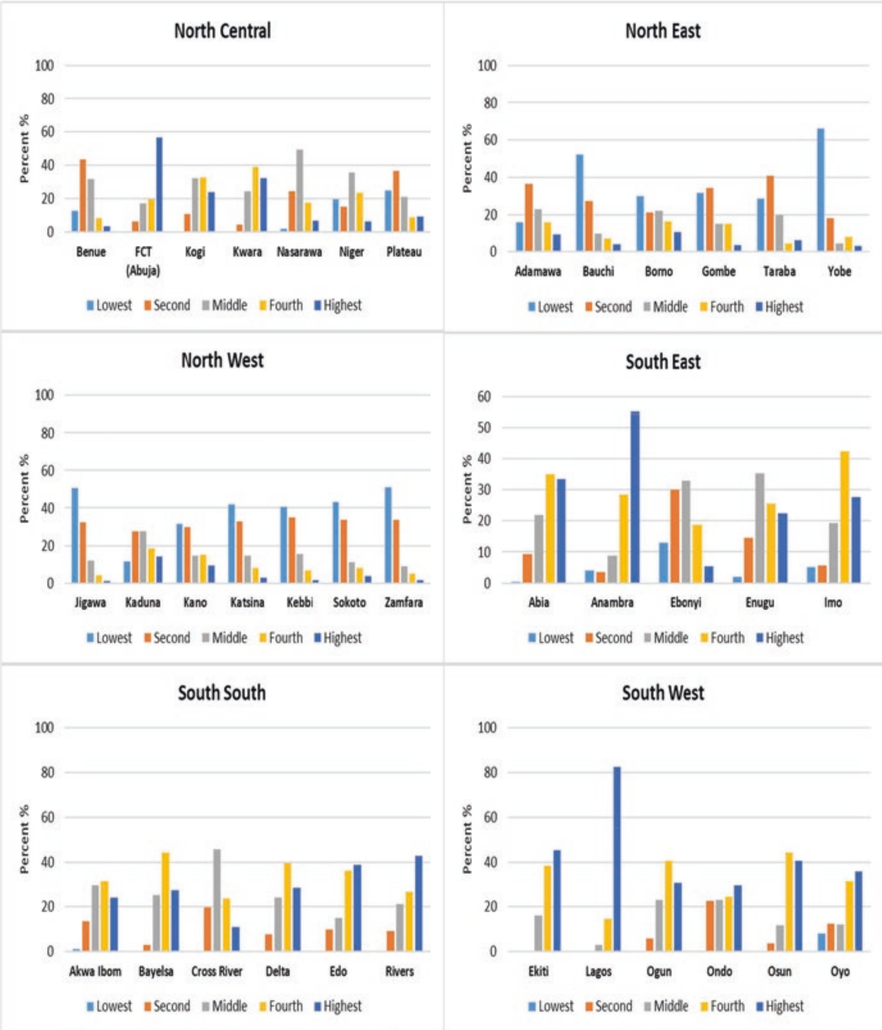

Fig. 15.12 Distribution of children born in the 5 years preceding 2013 NDHS by household wealth and state, Nigeria 2013

Bayelsa in the South South geo-political zone recorded a distinctively high percentage of home deliveries (76% in 2018). In retrospect, Bayelsa's delivery result is also like its ANC result, where proportions of children whose mothers did not attend ANC during pregnancy at 36, 52, and 47% in 2008, 2013 and 2018, respectively, were the highest in the southern region.

Further results on level of maternal care available in the country are shown in Table 15.7. It indicates that less than one-fifth of the children in the North West were attended to by a professional birth attendant during their delivery, unlike 85% of

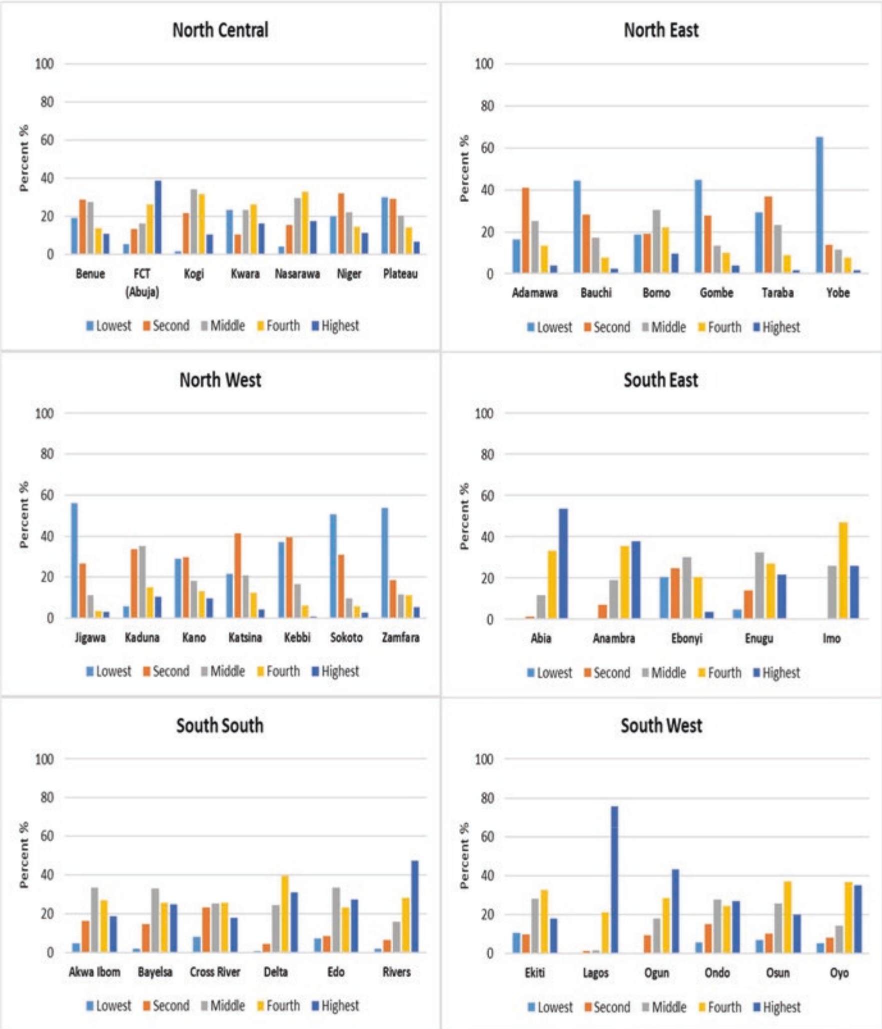

Fig. 15.13 Distribution of children born in the 5 years preceding 2018 NDHS by household wealth and state, Nigeria 2018

those in the South East and South West who received such care during delivery. State results further highlight the trend seen at the regional level. In the 2018 NDHS result, Kebbi and Sokoto in the North West had less than 10% assisted deliveries in stark contrast with more than 95% in Abia (South East), Imo (South East) and Osun (South West). Again, as seen earlier in results with ANC attendance and place of delivery, Bayelsa state also consistently had the lowest proportions of children whose births where assisted by a professional birth attendant amongst the southern states.

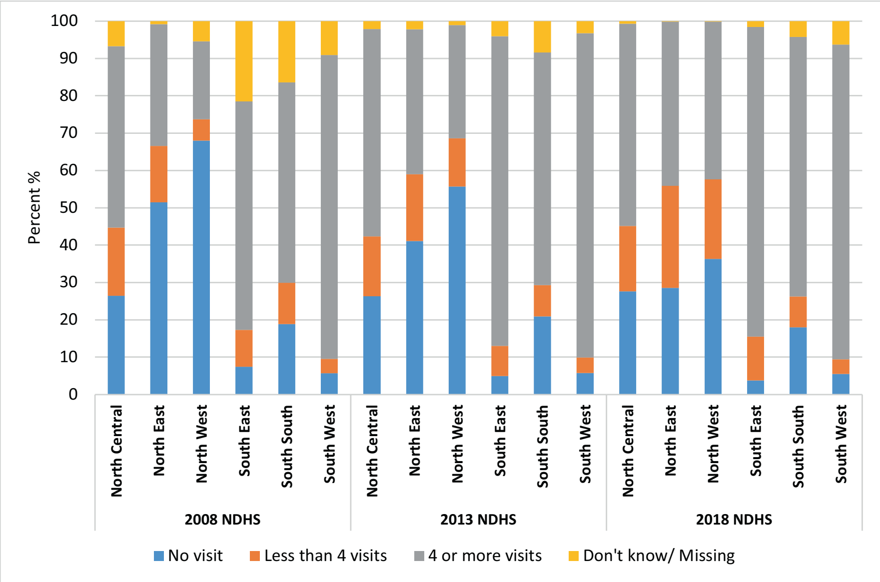

Fig. 15.14 Distribution of children born in the 5 years preceding each survey by mother's ANC attendance and geo-political zone, Nigeria 2008–2018

15.5 Discussion and Conclusion

Using the three most recent datasets of the NDHS, this chapter explored spatial differences in under-five mortality, as well as trends within geo-political zones and states over more than a decade and compared them with key socio-economic factors associated with under- five mortality. The results confirmed that mortality risks during infancy (0–11 months) are higher than mortality risks in the childhood period (between 12 and 59 months). Findings also echo the lack of progress in improving child survival in Nigeria during the study period. Additional sub-national analysis showed wide-ranging between-zone and within-zone disparities in under-five mortality. While the percentage of under-five deaths declined steadily in the South East, South South and South West throughout the study period, the reverse was the case in the North Central, North East and North West from 2013 to 2018. Generally, the proportion of under-five deaths were lowest in the South West and highest in the North West. With regards to trends, there were distinct patterns between states. This was an important finding, indicating that the increase in under-five mortality at the national level from 2013 to 2018 is disproportionately due to the situation in the northern regions.

Results on the study variables indicate that the North West had the highest proportion of under- five children born to women with no formal education, with as high as 73% in 2018 in sharp contrast to 3% in the South East. Similarly, the

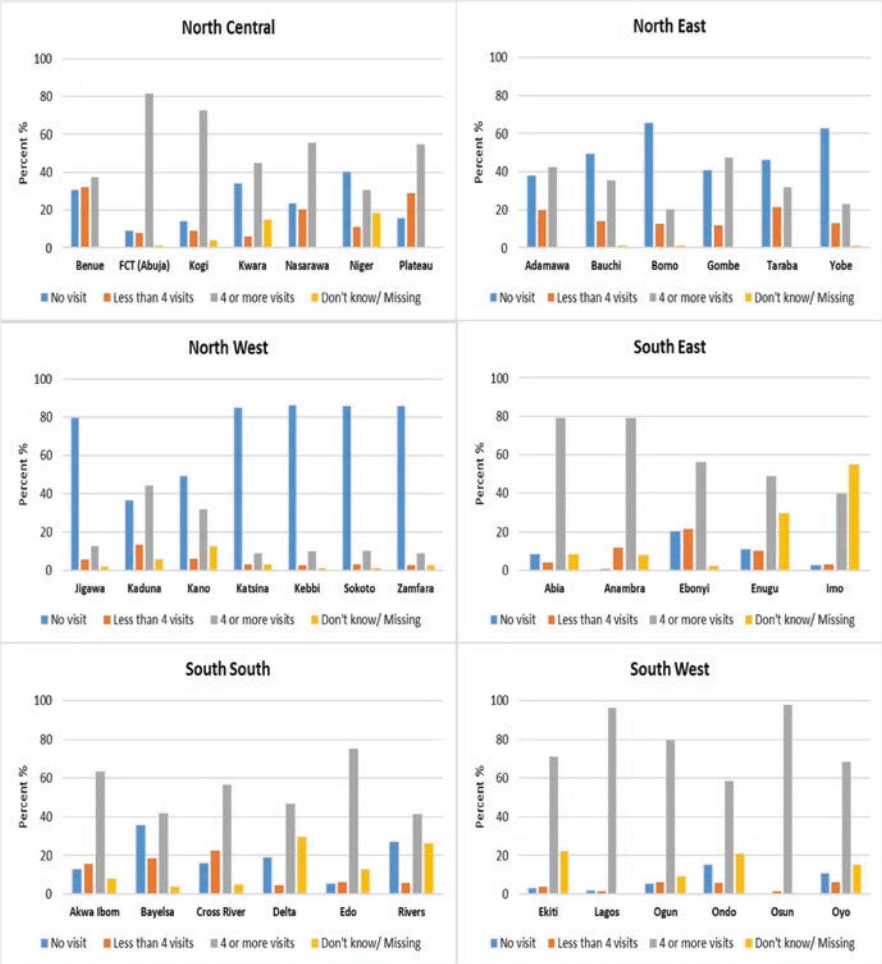

Fig. 15.15 Distribution of children born in the 5 years preceding 2008 NDHS by mother's ANC attendance and state, Nigeria 2008

northern regions had higher proportions of maternal women with no education, while the southern regions had higher proportions of maternal women with secondary or higher levels of educational attainment. Evidence shows that maternal education helps in controlling fertility, preventing early marriage and empowering women economically (Ezeh et al., 2015; Morakinyo & Fagbamigbe, 2017; Negera et al., 2013). Adebowale et al. (2012) added that, to a large extent, literacy cancels the effects of cultural and religious beliefs such as early marriage. As evident in the South West region, with a similar high proportion of Muslims to the north, the high level of female educational attainment reduces early marriage, unlike in the northern regions with lower female educational attainment and high child marriage. The

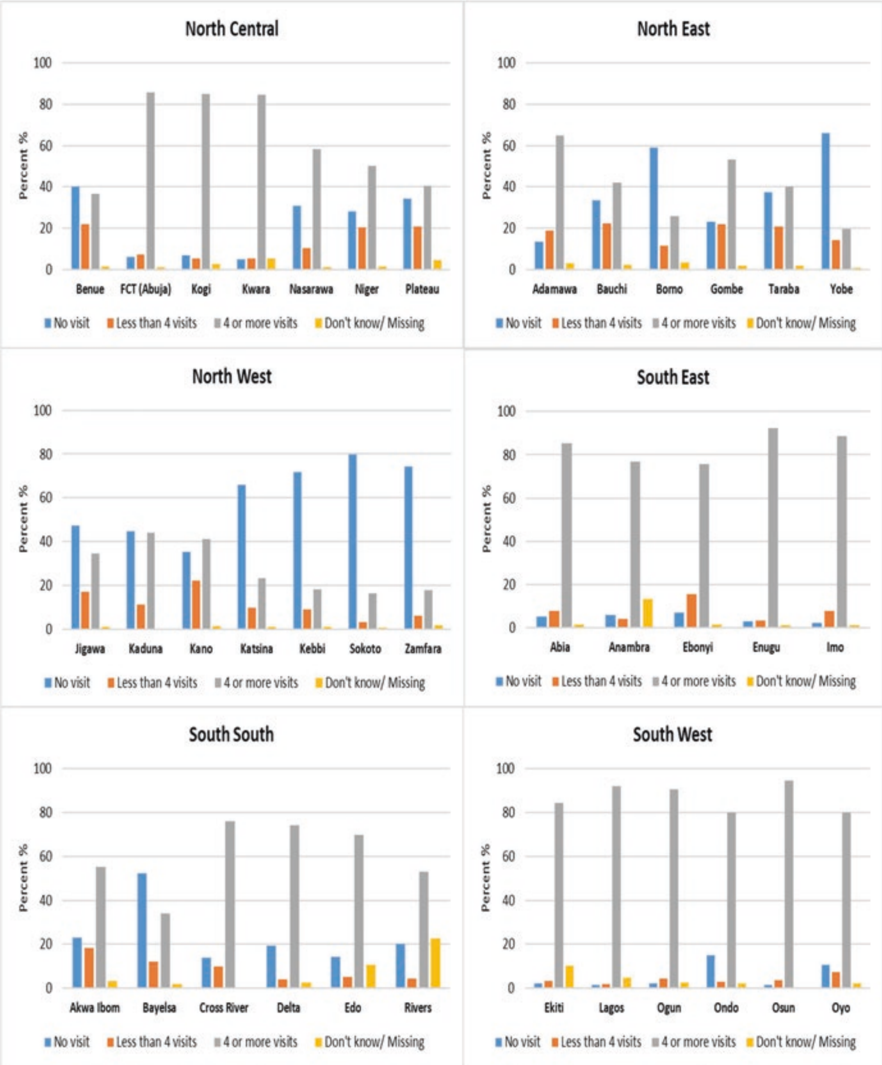

Fig. 15.16 Distribution of children born in the 5 years preceding 2013 NDHS by mother's ANC attendance and state, Nigeria 2013

practice of early marriage further limits women's access to education and participation in economic activities (Adebowale et al., 2012).

The North East and North West also reported higher proportions of children in households in the lowest wealth quintile, as well as higher wealth inequality, an indication of higher poverty spread and concentration of wealth with a few individuals. In addition to this pattern, the northern regions also reported higher proportions of children born to mothers who did not receive antenatal care, those that were

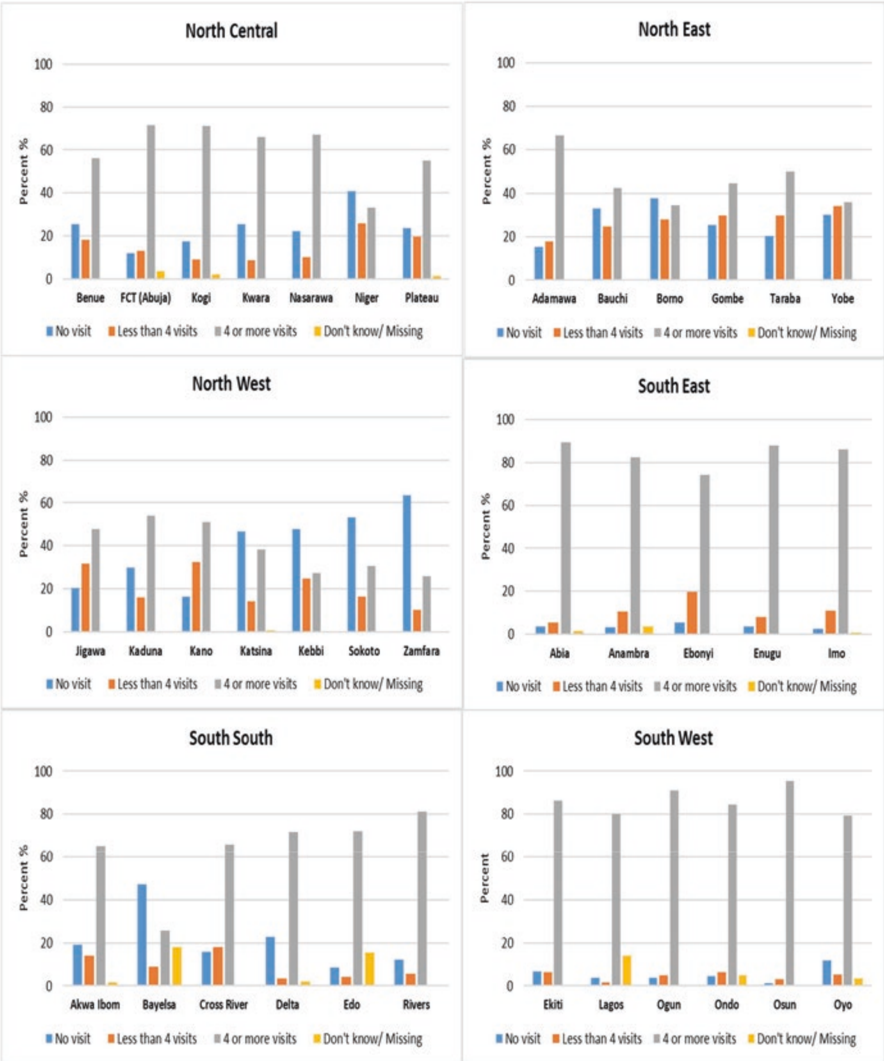

Fig. 15.17 Distribution of children born in the 5 years preceding 2018 NDHS by mother's ANC attendance and state, Nigeria 2018

delivered at home and without professional assisted delivery. A high of 84% of the deliveries in North West from NDHS 2018 were at home, further exposing the mother and new-borns to birth complications and infections due to unhygienic environment and lack of professional care.

Studies have shown that poor maternal education is associated with poor ANC attendance, which also reduces the chances of hospital delivery and assisted delivery by a healthcare professional (Doctor et al., 2011; Ononokpono et al., 2014).

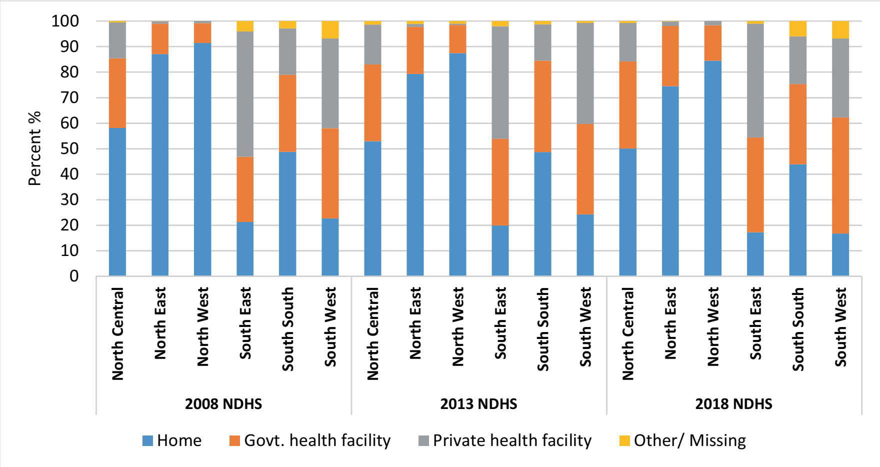

Fig. 15.18 Distribution of children born in the 5 years preceding each survey by place of delivery and geo-political zone, Nigeria 2008–2018

These imply that the clear inequality in under-five mortality by state cannot be considered in isolation from the socio-economic development at the states. Fetuga et al. (2007) added that socio-economic factors are associated with poor utilisation of health services. While those of lower socio- economic status and those resident in the rural areas are most affected by this, those of higher socio-economic status can afford private health care even if it is expensive, further widening inequalities in under-five mortality. Information on access to health care, which covers antenatal care, hospital delivery and assisted delivery, helps in addressing gaps to health care access in Nigeria. Aday and Andersen (1974) in their framework on access to medical care stated that access to health care was an interrelation of variables from health policy objectives to customer satisfaction.

To this end, if policies and interventions are not designed and implemented to address sub- national variations in under-five mortality at the state level, then under-five mortality levels in Nigeria would most likely continue to be high. Socio-economic gaps in the composition of individuals, households and communities at the states that are creating these inequalities in early childhood mortality should be addressed, otherwise the inequalities will persist. More importantly, factors such as socio-economic status and access to quality maternal and child health care need to be critically addressed. Findings across states should create more conversation aimed at addressing observed spatial variations in under-five mortality across the country. While policymakers and programme implementers need to prioritize action in the north, they should also target broad socio-economic development across states.

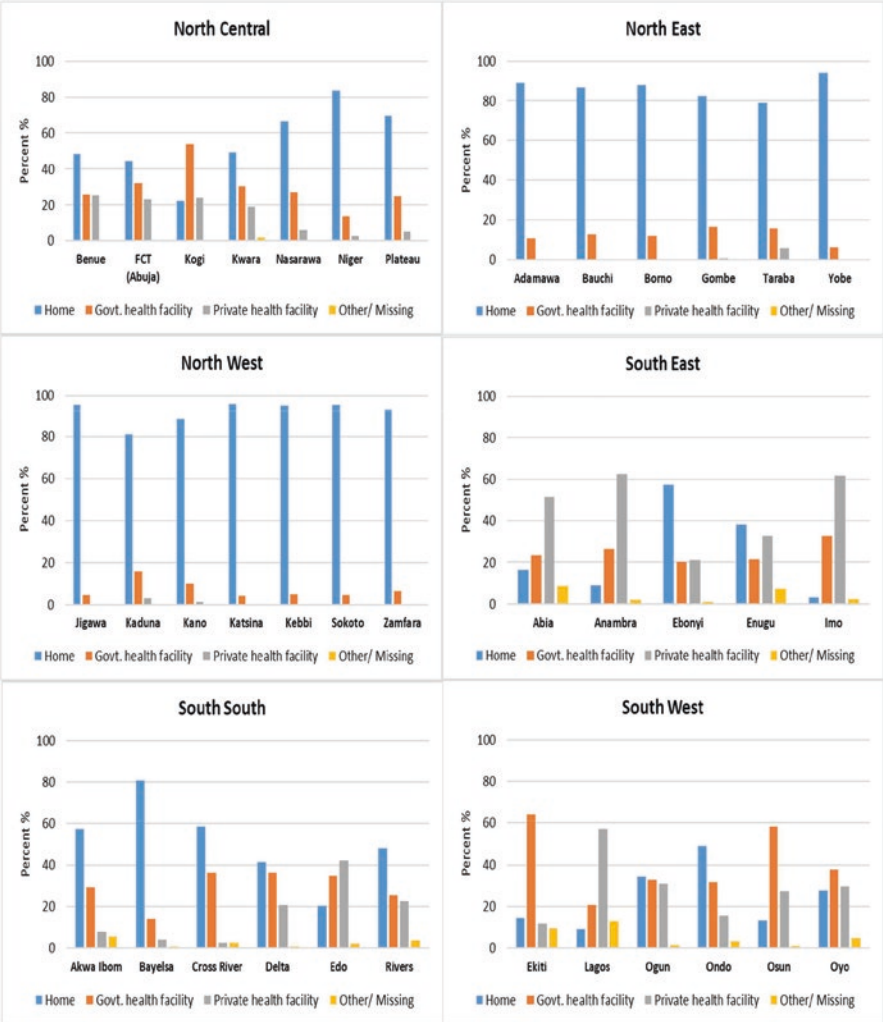

Fig. 15.19 Distribution of children born in the 5 years preceding 2008 NDHS by place of delivery and state, Nigeria 2008

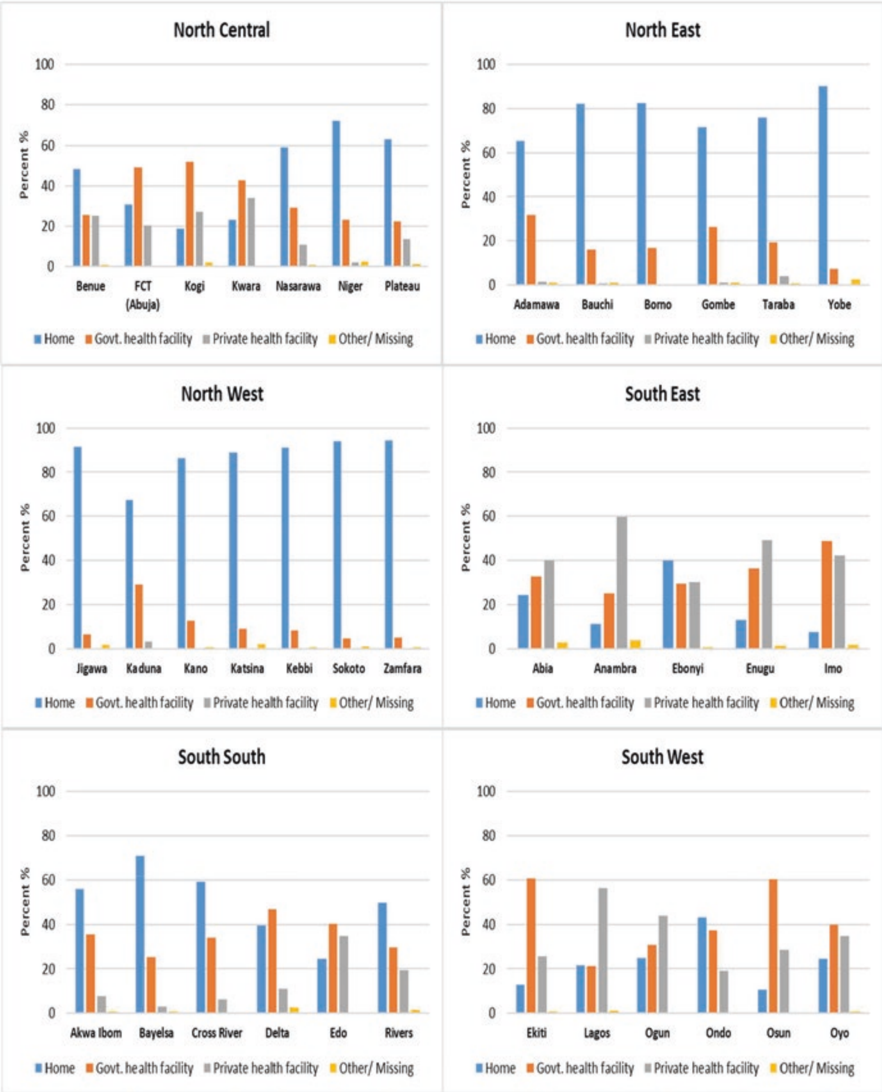

Fig. 15.20 Distribution of children born in the 5 years preceding 2013 NDHS by place of delivery and state, Nigeria 2013

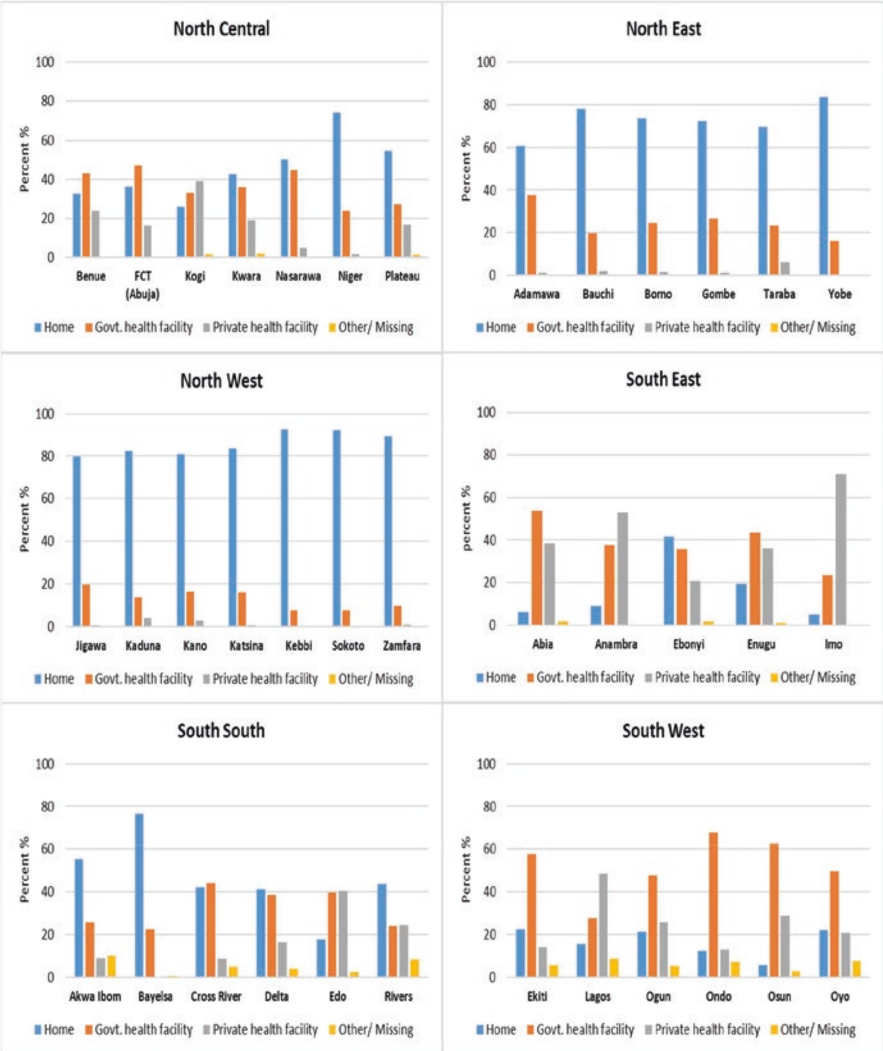

Fig. 15.21 Distribution of children born in the 5 years preceding 2018 NDHS by place of delivery and state, Nigeria 2018

Table 15.7 Sub-national distribution of children born in the 5 years preceding each survey by professional birth attendance during delivery, Nigeria 2008–2018

	2008 NDHS	2013 NDHS	2018 NDHS
Geo-political zone			
North Central	43.4	46.5	51.0
North East	15.7	19.9	24.8
North West	10.0	12.3	18.2
South East	82.9	82.2	85.2
South South	56.2	55.4	64.8
South West	77.1	82.5	85.4
State			
North Central			
Benue	52.8	51.6	67.6
(FCT) Abuja	65.8	70.2	71.6
Kogi	76.1	70.9	73.4
Kwara	53.6	79.6	62.1
Nasarawa	34.0	40.8	57.3
Niger	17.9	28.6	24.7
Plateau	30.9	35.8	42.9
North East			
Adamawa	14.8	36.3	40.5
Bauchi	16.0	16.3	21.6
Borno	13.4	22.3	25.9
Gombe	18.8	26.6	18.8
Taraba	26.0	14.3	30.4
Yobe	9.4	10.2	17.8
North West			
Jigawa	5.1	7.6	20.9
Kaduna	22.4	35.5	26.5
Kano	12.9	13.7	21.5
Katsina	4.9	7.7	18.9
Kebbi	6.4	9.3	3.4
Sokoto	5.2	5.4	9.2
Zamfara	7.8	6.1	12.5
South East			
Abia	88.1	77.2	95.8
Anambra	96.8	87.6	94.7
Ebonyi	47.1	62.1	52.1
Enugu	66.8	91.5	93.0
Imo	98.3	96.5	98.2
South South			
Akwa Ibom	44.1	45.6	41.4
Bayelsa	21.6	32.1	27.0
Cross River	45.3	41.3	55.7

(continued)

Table 15.7 (continued)

	2008 NDHS	2013 NDHS	2018 NDHS
Delta	61.6	59.8	67.1
Edo	81.0	78.3	88.2
Rivers	63.7	63.4	78.3
South West			
Ekiti	82.0	84.7	87.1
Lagos	83.9	87.2	83.6
Ogun	72.1	84.8	79.9
Ondo	51.1	67.3	86.1
Osun	89.6	94.2	96.0
Oyo	76.5	78.3	84.6

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Part IV
Location and Health Behaviour

Chapter 16
Sanitation, Health-Seeking Behaviour and Substance Use Among Street Children in Ibadan, Nigeria

Olukemi F. Awelewa

16.1 Introduction

The increasing incidence of street children has been attributed to rapid urbanisation, particularly in Africa, in recent decades (Adeojo, 2017; Burton, 2001; Dybicz, 2005). Poverty and family disintegration are some of the factors that have been associated with the proliferation of children on the streets of many urban centres around the world. However, to understand the dynamics of streetism, Ennew and Kruger-Stewart (2003), based on the (ILO, 2002) report on child labour, cautioned that rather than the simplistic assumptions that street children are either throwaways or runaways due to poverty or family breakdown, there are immediate, underlying and structural causes behind streetism. Immediate causes could be loss or drop in family income due to loss of job, illness, death or abandonment. Underlying causes could be from cultural/religious expectations, or the lure for bright city lights, and structural causes such as regional inequalities and social inclusion.

Although there has been extensive research on different aspects of street children, there are gaps in the areas of sanitation and healthcare, intersection of place, identity and some health choices of street children. The broad aim of this chapter is to examine sanitation issues, health-seeking behaviour and substance use among street children in Ibadan, Nigeria. Therefore, the study sought to answer the following research questions:

1. Do street children have access to good sanitation facilities and quality healthcare services in Ibadan, Nigeria?
2. What is the influence of place on street children, and how does this affect some of their health choices?

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3. What is the prevalence of substance use among street children in Ibadan, Nigeria?
4. Does substance use vary with street children's demographics in the study area?

16.1.1 Research Hypothesis

(i) There is no significant variation in street children's demographics and access to healthcare in Ibadan.
(ii) There is no significant variation in street children's demographics and substance use in Ibadan.

16.1.2 Study Area

Ibadan is the capital city of Oyo State in Southwestern Nigeria. It was one of the earliest settlements classified as an urban centre in Nigeria. The city was founded in the 1820s; its precolonial origin and the influence in later years of the British reflect the contrast that makes up the city (Mabogunje, 1968). Ibadan has been described as the largest truly indigenous urban centre in Africa, south of the Sahara, and the city displays a stupefying mix of old and new, of tradition and modernity, and this is reflected in the housing forms and settlement pattern within the city (Udo, 1994).

The 2006 national population census estimated the city population to be about 2.5 million, and the population at present is more than three million. Although the predominant ethnic group is Yoruba, a large proportion of the city population are migrants, many of which are poor, lack basic education with implications for access to employment opportunities, decent housing, healthcare and other social services (Adelekan, 2020). Ibadan owes much of its expansion to administrative, industrial, commercial and educational functions, and its choice as study area for the study was premised on the high level of urbanisation.

16.2 Conceptual Framework

This chapter situates streetism in the concepts of place and identity. Our imaginations about places oftentimes influence how residents of such places are conjectured. Johnston (1996) showed how crucial places are to the development of individuals as well as the influence that inhabitants also have in the making of places. He notes that places are crucial to the development of individuals and hence to their understanding. People become what they are because of where they are, and places become what they are because of the people who live in them. A place is the individuals' learning context, the arena in which they learn to be humans and act as such, and this is why place is crucial to the study of human geography.

Hence, people may be labelled deprived, deviant and dangerous or of low intelligence based on their locality (Taylor & Rogaly, 2009). This in turn affects how such people see themselves in relation to others and how they live their lives, including the health choices they make. Massey (1994) showed the essence of social relations in the construction of place and identity. She notes that there are various ways in which reference to place can be used in constructing the identity of an individual; she argues further that social relations always have a spatial form and spatial content. Time is equated with becoming and space/place with being. Jones and Garde-Hansen (2012) also showed the dynamics of place, identity and becoming; they portrayed place from both spatial and temporal dimensions. A place can be considered as identifiable, relatively stable and known physical spaces (city, neighbourhood, street, house) or conceived as ongoing temporal processes where several things combine and remain interconnected. One central argument in the theories of identity is the notion that identities are social products that internalise roles such as class, gender, ethnicity and sexuality and are rooted in the routine of day-to-day life. As such, human geographers have sought to understand the nature and meaning of identity since identities are both space forming and space formed (Warf, 2006).

The link between place and identity shows more often than not the stereotypes and public perception of street children as runaways, delinquents, substance users, etc. The categorisation of people based on the place they live/work in, in turn, shapes their self-identity and influence different aspects of their life including their lifestyle and health choices. Castellani et al. (2015) note the effects of geographical and cultural conditions in which people live as contextual factors against compositional factors such as age, education and household income on their health.

Kelly and Milward (2004) distinguished identity in two ways: public identity and private identity or self. Whereas public identity refers to how we are known, defined and understood as social beings in our interactions with others, private identity is the way we are known, defined and constructed by ourselves in interaction. When we speak of identity, we are not merely classifying; rather we are engaging in a complex series of meanings, intersections and possibilities of being and relating that notion to structure of social, political, cultural and economic life. Identity is not purely a self-constructed phenomenon; people have varied encounters at work or in social life which either challenge or confirm their identity (Agius & Keep, 2018; Kelleher & Cahill, 2014). Identities and subjectivities are a central area of interest in the subfield of children's geographies, and they are about who children and young people are in the contexts of their spatial experiences (Worth & Dywer, 2016).

16.3 Literature Review

Streetism is a major social problem that urban areas in many countries, those in developing countries in particular, are contending with. It is described as the manner of life of homeless or unmonitored youth on the streets (Arthur, 2013). The phenomenon of street children is complex. There is no general definition of street children; a street child has been defined as any boy or girl for whom the street has become his or her habitual abode and or source of livelihood and who is inadequately protected, supervised or directed by responsible adults (UNICEF, 1983). The Inter-NGO programme for street children and street youth defined a street child as any boy or girl who has not reached adulthood, for whom the street (in the broadest sense of the word, including unoccupied dwellings, wasteland etc.) has become his or her habitual abode and/or sources of livelihood and who is inadequately protected or directed by responsible adults. A street child is one who spends a substantial portion of his or her time on the street and whose survival depends on the street. The street fulfils some of the basic functions of home for sleeping, feeding, livelihood and entertainment (Dryjanska, 2014).

Classification of street children is also varied in extant literature. UNICEF (1983) classification was based on the degree of disconnection from their family. These are the "children on the street" and the "children of the street". Children on the street maintain family ties; they see their family regularly and may return to sleep at home at night. On the other hand, children of the street have almost no ties with their family and have no home besides the street. It is also interesting to note that while some children of the street left home due to one reason or the other, some are born on the street to older street girls (WHO, 2000). Other authors have also classified street children into more than two categories based on use, those making little use of the street, those for whom the street is a major resource and those whose survival completely depends on the streets (Williams, 1993). Rather than classifying street children based on existing categorisation, Dryjanska (2014) argued that classification should be based on research outcome.

There is no consensus both of the definition and the term street children in the literature. Some authors have argued that the nomenclature is problematic in terms of generalisation, which obscures their heterogeneity, and that their existence and experiences on the streets are not accurately depicted. They opined that the term is inappropriate and offensive and passes a distorted message. Moreover, the derogatory and pitying connotation results in a tendency to demarcate street children so radically from other groups of children in urban centres who live with their parents in similar or worse conditions. Governments and the media often stigmatise street children as lazy, delinquent drug users or romanticise/patronise them as pitiful victims of abandonment. However, majority earn their living by offering services to the society (Beazley, 2003; Dallape, 1996; Panter-Brick, 2002).

Although there is no consensus on the definition of street children, this subset of the population is vulnerable; they are exposed to hazards such as substance use, sexual and reproductive health problems and poor nutrition; and most are involved in one economic activity or the other. Moreover, there are no accurate data for street children due to the controversies surrounding who a street child is and also for their mobile nature. Globally, child labour is estimated at 160 million, 86.6% of children in sub-Saharan Africa are reported to be in child labour, while 38.6% are in hazardous work (ILO, 2020). The description of street children is suggestive of a working child, a school dropout or a homeless boy or girl (Volpi, 2002). However, not all work done by children should be classified as child labour. Children's participation in work not injurious to their health and personal development and education is wholesome for their development. Child labour refers to work that robs children of their childhood; is mentally, physically, socially or morally dangerous and harmful to children; and/or interferes with their education (ILO, 2002).

There has been extensive research on poverty and family background as causal factors of streetism (Fantahun & Taa, 2022; Ogunkan, 2021; Alem & Laha, 2021; Endris & Sidota, 2019; Issa & Bale-Robe, 2019; Isa & Madelyn, 2018; Genemo, 2018; Awartey, 2014; Ojelabi & Oyewole, 2012; Aderinto, 2000). Ennew and Swart-Kruger (2003) note that explanatory frameworks have become more sophisticated than earlier assumptions of street children being throwaways or runaways because of family breakdown and poverty. Studies have shown there are other causal factors such as conflicts and insecurities which put children and adolescents on the street (Kibret, 2015; Tefera, 2015).

16.4 Materials and Methods

For the purpose of the study, both children of the street and children on the street, as categorised by UNICEF, aged 9–18 years are included. Data for the study were collected over a three-month period between January and March 2022. The study employs a mixed method of structured questionnaire, interview and nonparticipant observation. The study areas and locations for data collection were purposively selected because they are urban areas within the city and the locations are notable places where street children converge. The study area covered the five urban local government areas in Ibadan metropolis; these are Ibadan South West, Ibadan South East, Ibadan North West, Ibadan North East and Ibadan North Local Government Areas. The study locations in these local government areas include Challenge/Scout-Camp Neighbourhood Market (Ibadan SW), Molete under bridge and environs (Ibadan SE), Dugbe (Ibadan NW), Iwo-Road (Ibadan NE) and Bodija Market (Ibadan N).

For the survey, the study adopts a convenient sampling procedure mainly because of lack of data on the number of the study population and also due to their highly mobile nature. The research instrument was a structured open-ended questionnaire. A pilot survey was conducted to test the workability of the research instrument at a motor park in Sango, Ibadan. The pilot survey helped in restructuring the questionnaire. All social research ethics were adhered to more so that the research subjects were minors. The participants were duly informed of the purpose of the survey, their consent (and that of their parents or adultguardians, where applicable) was sought and it was only those who gave their consent that participated in the survey.

The aim was to administer 50 copies of questionnaire in each of the 5 study locations; however, it was only in Challenge/Scout-Camp Market and Bodija Market that 50 copies of the questionnaire were completed. Only 31 copies of the questionnaire were completed at Molete; 42 and 36 copies of the questionnaire were completed in Dugbe and Iwo-Road, respectively, making a total of 209. Furthermore, interviews and observations were done to complement information collected with the questionnaire in locations where some of the study population settle either during or after the day's activities. Five street boys from the study sample were interviewed at Molete under bridge and environs; four street boys and one street girl were also interviewed at Scout-Camp neighbourhood market. Therefore, the number of people interviewed was 10.

The quantitative data were analysed using descriptive statistics such as frequency, simple percentages and charts. Chi-square test was used to test the hypotheses. Information from the interviews and observation were processed and presented as narrations.

16.5 Results and Discussions

16.5.1 Sociodemographic Profile of Street Children

More than half of the study participants were male (64.6%), while majority were between 12–14 years (39.7%) and 15–18 years (40.7%). Also, most participants were Yoruba (35.9%); majority (48.9%) earned less than ₦500 daily (Table 16.1). Results from the study revealed that there were more street boys than girls in the study area. Although this study did not strictly separate those that were living completely on the street from those that were only working on the street, majority of the female participants were hawkers who return home after each day's activities. Also, most of the participants earned less that ₦500 (<1 USD) daily. Previous studies have found the population of street boys to be more than that of girls and showed street children to earn very low income (Akanle et al., 2017; Cumber & Tsoka-Gwegweni, 2016; Ogunkan & Adeboyejo, 2014; Owoaje et al., 2009). Furthermore, majority of the street children were of the Yoruba ethnic group, and there were more Hausa/Fulani than Igbo and other ethnic groups.

The migration status of the street children showed that 50.2% were born and bred in Ibadan, 4.3% had migrated from other states in the southwest and the remaining had migrated from other places. Majority of the street children (besides those who had always lived in Ibadan) had migrated from the northern states. There were 2.4% others from the neighbouring country of Niger Republic. Most of the street children in Molete and environs, Bodija Market and Iwo Road Motor Park were Yoruba and had lived most of their life in Ibadan. However, the situation was different in Challenge/Scout-Camp Market and Dugbe Motor Park as majority of the street children in these locations had migrated from the northern states. Thirty-six percent of the street children in Challenge/Scout-Camp had migrated from Bornu, Yobe, Taraba, Kebbi, Adamawa, Plateau, Sokoto and Kano.

Table 16.1 Sociodemographic profile

Items	Number	Percentage
Gender		
Male	135	64.6
Female	74	35.4
Total	209	100
Age		
9–11 years		41
12–14 years	83	39.7
15–18 years	85	40.7
Total	209	100
Ethnic group		
Yoruba	75	35.9
Hausa/Fulani	37	17.7
Igbo	24	11.5
Others	73	34.9
Total	209	100
Migration status		
Ibadan	105	50.2
Other SW States	9	4.3
SE States	3	1.4
SS States	1	0.5
NW States	20	9.6
NE States	36	17.2
NC States	30	14.4
Others	5	2.4
Total	209	100
Daily income		
<₦500	87	48.9
₦500-₦1,000	42	23.6
>₦1,000	49	27.5
Total	178	100

16.5.2 Information About Family

Most of the study participants' parents were either separated or divorced (Table 16.2). Majority (60.3%) had both parents alive, and 65.6% of the fathers and 72.2% of the mothers had no formal education. Most of the fathers were working in low-paying occupations, 30.1% were artisans and majority of the mothers were traders (41.6%). Most of the participants came from large families with more than five siblings (65.1%). While majority of the street children were from broken homes, only 16.3% had both parents deceased. The low levels of education of parents of the street children explain their occupations as majority were involved in low-paying jobs besides a reasonable proportion that were not gainfully employed. Previous studies have

Table 16.2 Information about family

Items	Number	Percentage
Parent marital status		
Married	67	32.0
Separated	98	46.9
Divorced	44	21.1
Total	209	100
Family background		
Both parents alive	126	60.3
One parent alive	49	23.4
Both parents deceased	34	16.3
Total	209	100
Father education		
No formal	137	65.6
Primary	35	16.7
Secondary	21	10.1
Tertiary	13	6.2
Others	3	1.4
Total	209	100
Mother education		
No formal	151	72.2
Primary	29	13.9
Secondary	23	11.0
Tertiary	6	2.9
Others	0	0
Total	209	100
Father occupation		
Artisan	63	30.1
Trading	52	24.9
Farming	44	21.1
Unemployed	26	12.5
Commercial transport	12	5.7
Others	7	3.3
Teaching/Civil Service	5	2.4
Total	209	100
Mother occupation		
Trading	87	41.6
Artisan	51	24.4
Unemployed	45	21.5
Farming	16	7.7
Teaching/Civil Servant	8	3.8
Others	2	1.0
Total	209	100
Number of siblings		
No sibling	2	0.9
<5	71	34.0
>5	136	65.1
Total	209	100

shown that street children typically come from large families, broken homes, with parents of low educational and occupational status (Attia et al., 2017; Edinyang et al., 2020; Khanika et al., 2014).

16.5.3 Living and Working on the Street

Most (85.2%) of the street children were engaged in one economic activity or the other. Majority of those who were engaged were involved in hawking (44.4%) and commercial motorcycle/tricycle riding (20.8%). Similar to the variation in migration status of the street children at the different locations, there were variations in their economic activities. Majority of the older migrants from the northern parts in Challenge/Scout-Camp Market and Dugbe motor park were mostly engaged as commercial motorcycle riders, hawking, mobile cobblers and well diggers, while some of the younger ones washed car windscreens or begged alms on the pavements. Majority of those at Bodija market and Iwo Road were engaged in hawking and porterage, while the older street children at Molete and environs were mostly engaged in commercial tricycle riding, lotto/betting and bus conducting, and the younger ones were mostly hawkers and beggars (Fig. 16.1).

Table 16.3 showed that majority (54.6%) of the street children had either lived or worked on the streets between five and seven years, and most of them were on the street due to lack of parental support. It is noteworthy that a large proportion of the participants were on the streets due to lack of parental support, notwithstanding that only 16.3% had both parents deceased. Some of the children who were still schooling also worked on the street to provide additional financial support to their family.

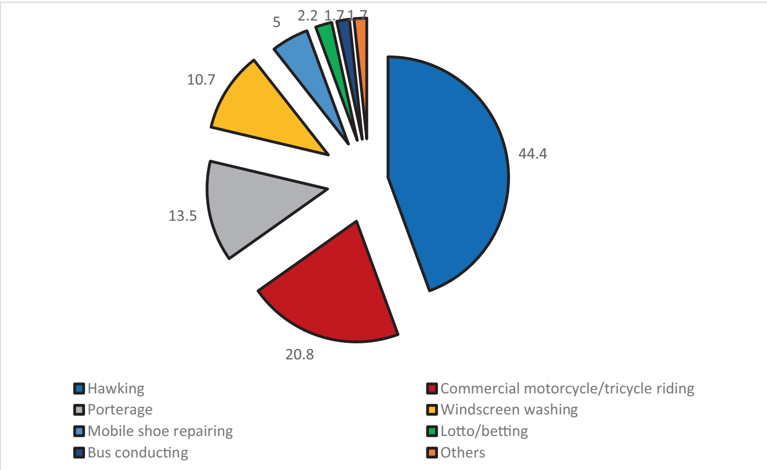

Fig. 16.1 Types of employment. (Source: Author's Analysis, 2022)

Table 16.3 Living/working on the street

Items	Number	Percentage
Year lived/worked on the street		
<2 Years	36	17.2
5-7 Years	114	54.6
>7 Years	59	28.2
Total	209	100
Reasons for living/working on the street		
Lack of parental support	134	64.1
Additional financial support for family	27	12.9
Conflict/Insecurity	24	11.5
Parent's occupation	18	8.6
No response	6	2.9
Total	209	100
Exposure to danger/hazards on the streets		
Yes	176	84.2
No	33	15.8
Total	209	100
Types of danger/hazards exposed to		
Road accident	105	60.0
Physical assault	24	13.6
Sexual assault/harassment	21	11.9
Theft/robbery	13	7.4
Police raids	8	4.5
Others	5	2.8
Total	176	100

The migrant street children from the northern parts of the country indicated conflict and insecurity due to insurgency as one of the reasons for being on the street.

Moreover, 84.2% indicated that they were exposed to dangers and hazards living/working on the streets. The study results have revealed that majority of the street children are engaged in legitimate economic activities. They are exposed to different kinds of danger as they struggled to survive on the streets. Those that hawked in traffic as well as the motorcycle riders indicated road accident and physical assault. Street children who work at busy intersections have been shown to be significantly exposed to toxic chemicals (BTEX-benzene, toluene, ethylbenzene, p-xylene and m-xylene) (Rafiee et al., 2022). The street girls indicated sexual assault/harassment from customers. Amoo et al. (2016) showed that young girls who are involved in street trading are exposed to sexual harassment with increased propensity for higher prevalence of HIV/AIDS in Nigeria.

Theft/robbery and police raids were also other forms of hazards of living/working on the streets reported. Street children have been reported as targets of police raids; McAra and McVie (2005) note that the police may be unfairly targeting certain categories of young people, and it appears that they make distinctions about who can be shown leniency and those who cannot based as much on socioeconomic status as serious and persistent offending. They argued that policing of children in this manner may serve to sustain and perpetuate the very problems which they seek to contain and eradicate. The case of the infamous Special Anti-Robbery Squad (SARS) readily comes to mind as the squad made many indiscriminate arrests of young people based on mere appearance. A street boy at Molete, aged 17 years, who worked as a tricycle operator reported regular police harassment even while going about his daily economic activities. These evidences showed that street children are exposed to various kinds of hazards with grave social and economic implications.

16.5.4 Access to Basic Education, Healthcare and Housing

Almost half of the participants had no formal education; Nigeria reportedly has one of the highest number of out-of-school children globally. Although some of the study participants claimed they were still in school, many of them were interviewed on school days and during school hours. Similarly, a very large proportion (91.9%) did not have access to healthcare (Fig. 16.2). Out of the few that had access to healthcare, only 23.5% indicated they were using public healthcare facilities, while 76.5% indicated private facilities. Majority of those who reported no access to healthcare services relied on self-medication in cases of ill-health (Fig. 16.3). Previous studies have shown a high prevalence of skin, respiratory and other infections among street children due to lack of access to quality healthcare services (Eshita, 2018; Mukherjee et al., 2006; Rizk et al., 2017; Zenu et al., 2019). Other studies have also shown that the commonest treatment available to street children in cases of ill-health is self-medication (Oktavialia, 2020; Rivenbark et al., 2018).

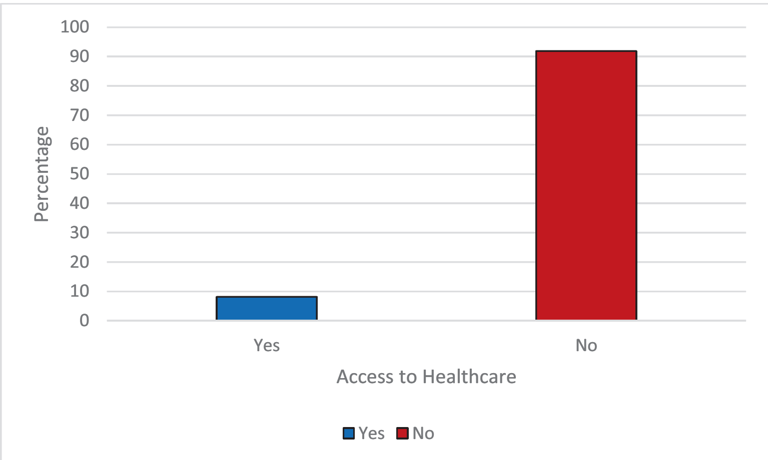

Fig. 16.2 Access to healthcare. (Source: Author's Analysis, 2022)

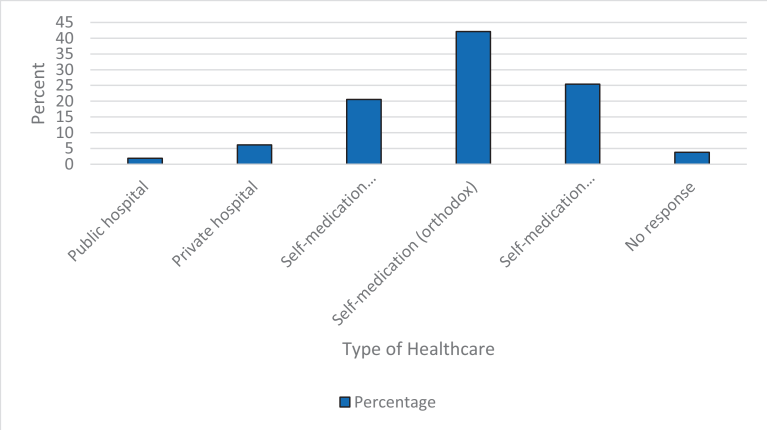

Fig. 16.3 Type of healthcare. (Source: Author's Analysis, 2022)

Table 16.4 Housing and sanitation

Housing	Number	Percentage
Place of residence		
City core	131	62.7
City suburbs	25	12
In-between city core and city suburbs	53	25.3
Total	209	100
Type of living quarters		
Makeshift structures	18	8.6
Market stalls	48	23
Rented communal compound	76	36.4
Personal family house	67	32
Total	209	100

The study sought to examine variation of access to healthcare and family background among the participants. Although those who were living with both or either parent had better access to healthcare, the chi-square test result showed no significant variation ($X^2 = 4.044$, $df = 2$, $p = 0.132$, $p < 0.05$).

Table 16.4 showed that majority of the street children (62.7%) were living in high-density residential areas of the inner city that had no basic amenities such as toilets and baths. Only a few had access to toilet/bathing facilities (Fig. 16.4); most of the participants were defecating in close/open spaces and streams/rivers (Fig. 16.5). Moreover, 72.2% of the participants were bathing in open spaces. The high percentage that defecates in open spaces as well as streams and river channels is quite worrisome considering the implications for population health.

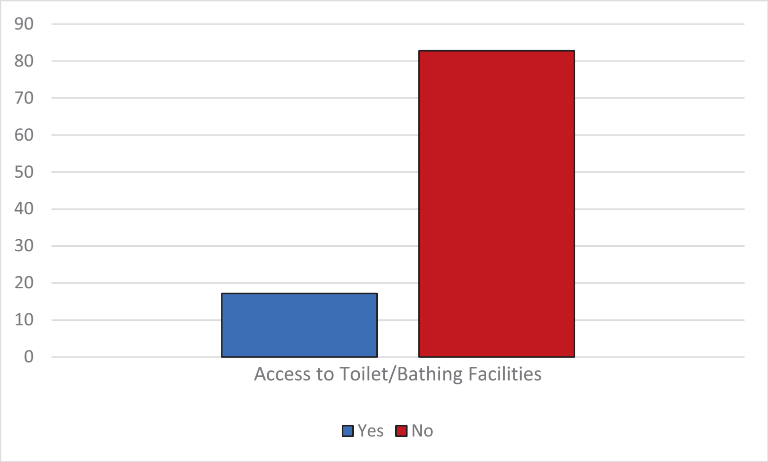

Fig. 16.4 Access to toilet/bathing facilities. (Source: Author's Analysis, 2022)

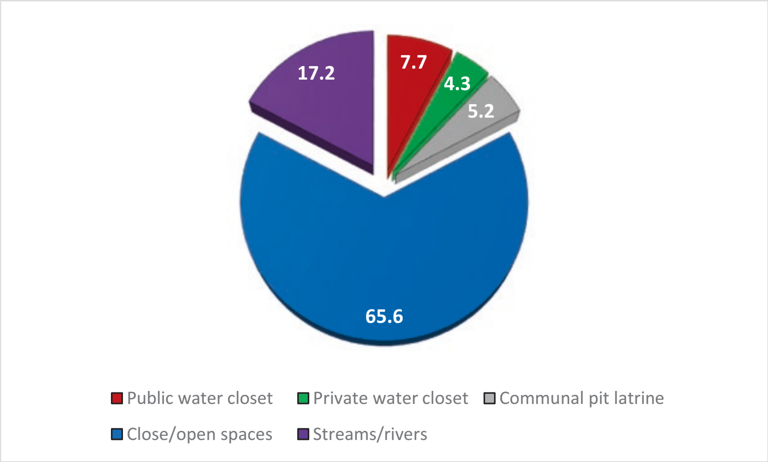

Fig. 16.5 Type of toilet facilities. (Source: Author's Analysis, 2022)

16.5.5 Identity, Social Relations and Substance Use

Table 16.5 showed that the participants had extensive networks on the streets; majority were living/working with other children. Street children are known to build social relations and networks as surrogate family for comradeship and survival on the streets (Amoah & Jøgensen, 2014; Rahman et al., 2018). Almost half of the street children aged 9–11 years saw themselves differently than other children who are not living/working on the street; a small proportion of the older street children see themselves as differently from other children probably because they have been

Table 16.5 Identity and social relations

Living/working with other street children	Number	Percentage
Yes	187	89.5
No	22	10.5
Total	209	100
Number living/working together		
2 persons	16	8.6
3–4 persons	45	24
5–7 persons	85	45.5
>7 persons		41
Total	187	100
Identity (Different from others?)		
Yes	82	39.2
No	127	60.8
Total	209	100
Difference from others		
Out of school	27	32.9
Lack of care/leisure/recreation	19	23.2
Public perception	36	43.9
Total	82	100

on the street for longer periods of time and have been well adapted to life on the street. Some saw themselves differently because they were out of school, and among this group were some who had not dropped out of school completely but attended classes haphazardly because they had to work for sustenance. Others' self-perception was based on lack of care, leisure and recreation, as well as public perception. Ogunkan and Adeboyejo (2014) reported negative perception of street children and how this reinforces their negative image as delinquents. The fact that almost half of the participants saw themselves differently based on public perception shows that identity is not purely a self-constructed phenomenon (Kelleher & Cahill, 2014).

The older street children's identity is projected in their general outlook. The males mostly wear ripped jeans popularly referred to as crazy jeans, and sagging is also a popular culture among them. The street boys interviewed at Molete had similar haircuts known as dreads, and those interviewed at Molete and Scout-Camp Market shared strong bonds and counted on one another for emotional, financial and other forms of support. One street boy at Molete said:

awon temi leleyi…these are the only family I know. (Muda, age 17 years)

Only 8.1% had any exposure to substance use prior to living/working on the street; however, more than half had been exposed to substance use since living/working on the street (Fig. 16.6). More than half (51.7%) of the participants were exposed to a mixture of alcohol and other illicit substances, 20.3% to marijuana, 9.3% to tobacco and alcohol and 18.7% to others. The illicit substances and alcoholic cocktails have coded street names such as Ref (Rophynol), Codeine, TM

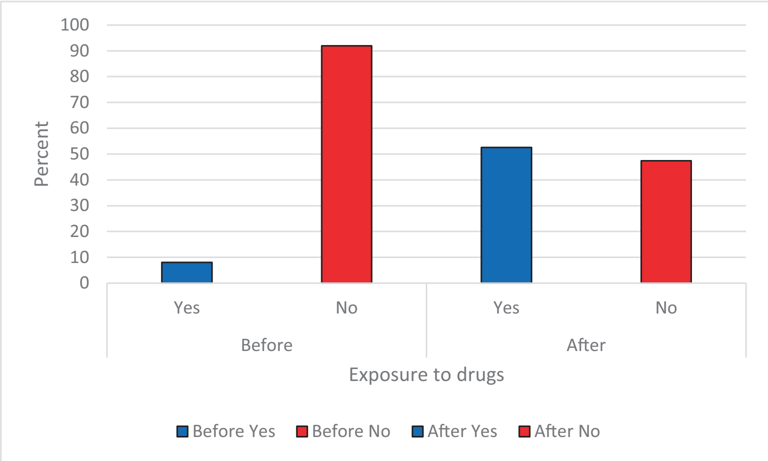

Fig. 16.6 Substance use. (Source: Author's Analysis, 2022)

(Tramadol), Ice, Loud, BK (Banku), Arizona, Gia, Shaike, Colorado, Mamba, Skonk, Kush, Gum, Pelebe, etc. Previous studies have also reported high prevalence of alcohol and other illicit substance use among street children (Abate et al., 2020; Jakaza & Nyoni, 2018).

The study sought to examine whether there is a significant variation in some of the participants' sociodemographic characteristics. Generally, 56% were exposed to substance use, but there is a wide variation between the genders. Results revealed that more male (80.7%) than female (10.8%) were abusing a range of harmful substances, and the chi-square test result showed a significant variation in gender and substance use ($X^2 = 94.856$, $df = 1$, $p = 0.000$ at $p < 0.05$). This finding is similar to Dosumu, Olumide and Omotade (2016) who found a high prevalence of substance use (62%) and gender as one of the factors associated with substance use among street children in Ibadan. There was also a significant variation in age and substance use among the participants ($X^2 = 11.265$, $df = 2$, $p = 0.004$, $p < 0.05$). The older street children aged 15–18 years were almost four times more likely to abuse harmful substances than the younger ones. Previous studies have shown that substance use increases with age of street children (Islam et al., 2014; Asante et al., 2014).

Furthermore, results showed a significant variation in family size and exposure to substance use ($X^2 = 6.747$, $df = 2$, $p = 0.034$ at $p < 0.05$), but there was no significant variation in family background and substance use ($X^2 = 2.010$, $df = 2$, $p = 0.366$ at $p < 0.05$). Drug and alcohol use was reported by some of the street children interviewed as one of the ways new and younger members are socialised into life on the street. This is clear from the sharp increase in the percentage of substance users since living/working on the street. Moreover, some claim they use these substances due to the nature of their jobs. A participant at Scout-Camp Market said:

> I started using 'taba' and 'shaike' and others after I started commercial motorcycle riding. Initially, I used to feel very tired at the end of the day's work, and I still will be unable to

> have a sound sleep. When I saw that my friends that also ride commercial motorcycles who were taking these substances were not feeling as tired and sleeping better that I was, I began to take them too. (Musa, age 16 years)

16.5.6 Streetism, Health and Development

The United Nations Agenda for sustainable development commonly referred to as the Sustainable Development Goals (SDGs) was adopted in 2015 as a blueprint for peace and prosperity for people and the planet in the present and into the future. The African Union Agenda 2063 Goals is another blueprint for development of the continent. These global and continental development agenda have at their front burners quality education, health, clean water and sanitation, etc. which are prerequisites for sustainable development. However, many years after the adoption of the goals, for millions of people, those in the developing countries in particular, access to basic amenities such as education, decent housing and healthcare is still very poor.

Nigeria's population age structure is youthful. In 2021, the World Bank put the proportion of the population under 15 years at 43%, and 10.5 million aged 5–14 years are out of school. It is reported that one in every five of the world's out-of-school children is in Nigeria. In line with the 1989 UN Convention on the Rights of the Child and the African Charter on the Rights and Welfare of the Child, the Child Rights Act came into being in 2003, and among other rights to be effected are right to health and health services, right to parental care, protection and maintenance and right to free, compulsory and universal primary education. The Act criminalises harmful practices such as exposure to use, production and trafficking of narcotics and psychotropic substances and various forms of sexual abuse. Unfortunately, almost 20 years since the Child Rights Act, there are some states that are yet to domesticate the laws, and in states where the Act had been domesticated, the laws are yet to fully translate into tangible development for the child.

Results from this study have shown that majority of the participants have no formal education, and those that are in school are not completely there as they had to work to supplement the family income. A vast majority did not have access to healthcare; most of the children practise self-medication, combining orthodox and traditional medicine in some cases. Many of the participants indicated they buy drugs from vendors when ill. Ladi-Akinyemi and Ajayi (2017) showed that chronic use of analgesics and herbal concoctions are risk factors for chronic kidney diseases. Moremi et al. (2017) also showed that the use of local herbs and spending day and night on the street were predictors of extended spectrum beta-lactamase (ESBL) producing Enterobacteriaceae among street children in Tanzania. They reported a high prevalence of the bacteria among street children who rarely had any contact with healthcare facilities.

Moreover, many of the participants had no access to proper housing. Over 30% were living in makeshift structures in markets, motor parks and uncompleted buildings. For those who were living in rented and family houses, most of the houses had no toilet and bathing facilities. Majority practice open air defecation in the markets and motor parks as well as in streams and rivers. It is noteworthy that many of them bathe in the same contaminated streams and rivers. Street children's practice of swimming in contaminated water bodies is one of the factors associated with prevalence of intestinal parasitic infections (Zenu et al., 2019). Previous studies on housing and sanitation in Ibadan showed that there is outright lack or inadequate sanitary facilities in many houses particularly in the city core (Ogundele et al., 2018; Oloruntoba et al., 2019; Popoola et al., 2015). Contamination of vegetables has been shown to be attributable to poor sanitation where soil and water can be contaminated with human faecal matter (Obebe et al., 2020). It is clear from past episodes of disease outbreaks that this has serious implications for public health. Adelekan (2020) remarked that Ibadan has very inadequate water and sanitation coverage. Many wells are unfit for human consumption based on their proximity to pollution sites such as pit latrines and solid waste dumps, as well as unsanitary practices and flood overflow. Lack or inadequate access to basic services such as healthcare coupled with poor sanitation increases risks of waterborne diseases such as diarrhoea and cholera.

Furthermore, there is increasing prevalence of chronic kidney disease in Nigeria, and the lifestyle risk factors include alcohol and substance use among others (Akokuwebe et al., 2020; Dunkler et al., 2015; Vupputuri & Sandler, 2003). More than half of the participants were abusing harmful substances for various reasons such as peer pressure, coping strategy for life on the street and recreation. Majority of the older boys were taking an assortment of tobacco, alcohol, psychotropic substances and others. These practices have also been reported to be associated with poor mental health outcomes (Hills et al., 2016; Jones et al., 2016; Smith et al., 2017; Hines et al., 2020).

16.6 Conclusion

Children's physical, social and other needs must be met for proper growth and development, but there are various threats to this in the society. The growing challenge of streetism has dire consequences at all levels. Street children have poor access to some of the most important basic services such as education, proper housing and quality healthcare. The fact that majority do not have basic education shows the likelihood that the next generation may also not have access to education; thus, the vicious cycle continues. Health is a very important aspect of well-being, and man's productivity to a large extent depends on good health. WHO (1978) defined health as a state of complete physical, mental and social well-being, and not merely an absence of disease or infirmity. Street children lack access to good quality healthcare required for physical health; they indulge in all sorts of unhealthy practices that not only predispose them to poor physical but also poor mental health outcomes. According to the World Health Organisation (1948) declaration, health is a fundamental human right, and several countries in Europe offer universal healthcare coverage to their citizens, but in Africa, access to healthcare is mostly through out-of-pocket payment, thereby taking healthcare out of the reach of disadvantaged groups in society.

The youth in any society constitute immense potential human resource required for development. Although there are no reliable data on the number of street children both at the city and national levels, there are evidences to show that a large number of children are living on and off the street; they are involved in hazardous works, lack basic amenities and are exposed to harmful substances. Street children are a part of the population whose health needs ought to be prioritised, but when a significant part of this population are deprived of basic essential services, the ripple effects are substantial at all levels. The Nigerian population age-structure being youthful ought to be harnessed for national development.

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Chapter 17
Human Geophagy (Soil Ingestion): Biochemical Functions and Potential Health Implications

Tsholofelo L. Molale and Peter N. Eze

17.1 Introduction

Nutrition as a biochemical and physiological process supports all lives on earth by providing the nutrients and energy needed for day-to-day survival. The United Nations (UN) recognized and highlighted the need for adequate nutrition in the second Sustainable Development Goal (SDG 2) which seeks to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture (UN, 2015). Although it is clear that effective tackling of malnutrition and hunger will undoubtedly go a long way in the quest to ensure prosperity for all, this has not been sufficiently addressed on the African continent due to fundamental setbacks such as poor education (Mukudi, 2003), poverty, lack of economic opportunity and traditional gender roles (Watson et al., 2021). Given that malnutrition can have severe negative implications on human health, which could hinder the overall development of Africa, it is vital to characterise all materials consumed by both humans.

Geophagy, also known as geophagia, is the habitual ingestion of earthy materials such as chalk, clays and termite mounds. It is a form of pica (Ekosse & Anyangwe, 2012). The term pica comes from the word, 'magpie', a Latin word for a bird well

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known for eating non-food matter called a magpie (Msibi, 2014). Globally, soil ingestion has been an issue of concern for soil scientists and health professionals alike and is seen as enigmatic (Henry & Cring, 2013). Although the practice of geophagy has been documented worldwide for at least two millennia, it has been mainly associated with tropical areas (Abrahams, 2002) and the African continent (Abu et al., 2017). In these areas, the practice of geophagy cuts across cultural backgrounds, socio-economic status and religious affiliations (Msibi, 2014; Abrahams, 2002; Diko & Siewe, 2014). However, it is mainly observed in young children of school-going age and pregnant women from poor socio-economic backgrounds (Hooda et al., 2004; Garg & Sharma, 2018). Ingestion of soil may be intentional or non-intentional due to the different manners in which components of soil could enter the human body (Young et al., 2010). In addition to deliberate ingestion, other pathways include inhalation of air-suspended soil particles and skin contact (Odangowei & Okiemute, 2019).

Ingestion of soil is strongly connected with rituals, traditions and religions. Hunter-Adams (2016) outlined three possible causes of geophagy as hunger, micronutrient deficiencies in the body and protection against harmful plant chemicals and/or microbes. Although it was suspected that the ingestion of earth material was a result of mental or physical sickness, the myth was discredited because soil fulfils physical and emotional needs (Hooda et al., 2004). The deficiency of micronutrients may be an incentive to eat soil to increase iron (Fe), zinc (Zn) or calcium (Ca) in humans (Young et al., 2010). These mineral nutrients can be provided directly to geophagists from ingestion. It has been suggested that geophagy is a response to nutritional deficiency in the form of the craving for non-food substances (Abrahams, 2002). Other factors including the taste of soil, curiosity and recommendation from peers have been identified as potential driving factors of geophagy in women.

Craving soil and its ingestion is most likely to occur in the early stages of pregnancy (Garg & Sharma, 2018), whilst other forms of pica are most likely to develop in the third trimester (Young et al., 2010). Oftentimes, pregnant women ingest soil to deal with nausea, vomiting and stomach/abdominal pains (Intiful et al. 2016). On the other hand, geophagy in young children can be hard to identify as they tend to put anything in their mouths at very young ages (Gundacker et al., 2017). Reports show that geophagy in mothers during pregnancy was a significant connection with the child's habit of soil ingestion (Kmiec et al. 2017). The practice of geophagy during pregnancy exposes the mother and foetus to environmental contaminants such as toxic elements, helminthic and other infections (Owumi & Oyelere, 2015).

Until recently, the significance of soils to human well-being has been largely underestimated. Given that soils vary in time and space (Phillips, 2017; Eze, 2022), the amount of soil ingested has to be accurately estimated, that is, they should not be based on previous research from different continents, times and demographics. Numerous soils are to be overviewed and characterised in detail; a few geophagic soils have been, to a great extent, understudied (Abrahams, 2002). Geophagic products without information such as recommended dose, period and duration of intake (pregnancy trimesters, days/weeks/months) and consumption pattern are sold to consumers. These are usually collected from urban and/or developing areas where there is a high probability of contamination and have great risk factors for communicable and non-communicable diseases (Orisakwe et al., 2020). As the African continent strives towards achieving the SDGs of good health and well-being for all ages and improved nutrition and soil consumption, a widespread practice cannot be overlooked. This chapter, therefore, explores the prevalence, biochemical functions and human health implications of geophagy. Geochemical methods and indices applied in evaluating the potential risks are also discussed.

17.2 Prevalence of Geophagy in Africa

As earlier stated, geophagy is very prominent in Africa. The geographical distribution of reported cases is presented in Fig. 17.1. By convention, geophagic soils are carefully collected looking at their appearance, taste and texture (Henry & Cring,

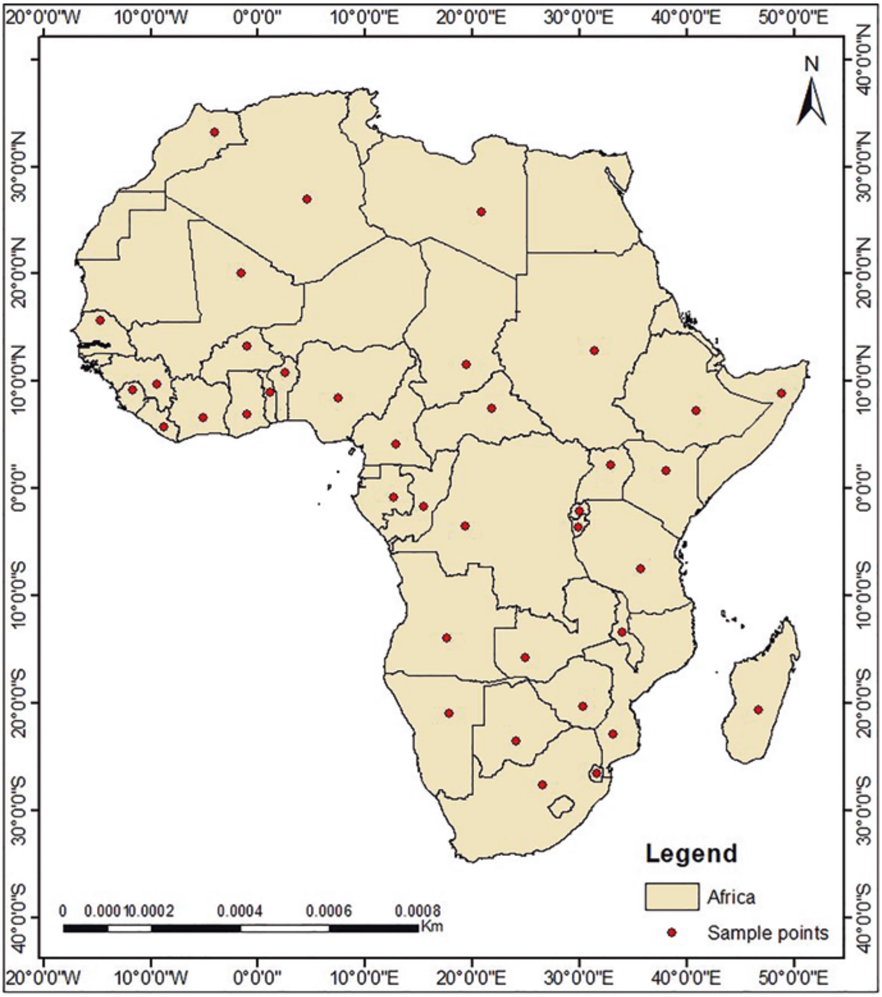

Fig. 17.1 Map of Africa showing (red dots) geophagic practices

Fig. 17.2 Geophagic termite mound in Mochudi, Botswana

2013). Anthills, termite mounds and clay deposits (Fig. 17.2) are some of the sources of ingested soils (Eze et al., 2020). African countries where geophagy has been widely reported include Nigeria, Kenya, Cameroon, Ghana, Guinea, Ivory Coast, Malawi, Senegal, Sierra Leone, South Africa, Tanzania, Uganda, Swaziland South Africa, Zimbabwe, Zambia and Togo (Young et al., 2007; Ravuluvulu, 2018; Walker et al., 1997; Odangowei & Okiemute, 2019; Kambunga et al., 2019).

Geophagic soils can be bought at local markets (Fig. 17.3) for consumption where they are specially prepared by selecting the material, processing, cooking and finally shaping it favourably for ingestion (Crawford & Bodkin, 2011). Geophagic clay is mined in the West African sub-region (Nigeria and other sub-Saharan states including Ghana) and sold in open markets as it has proven to be vital for the livelihood of the local people (Orisakwe et al., 2020). In Cameroon, for instance, they are commonly called 'Calabar chalk', named after Calabar, a city in southern Nigeria known for mining and selling geophagic clays (Odangowei & Okiemute, 2019). A town in Nigeria produces 500 tons of soil annually for consumption in West Africa (Roy et al., 2018). To date, rummaging for geophagic material remains a source of income for most rural residents (Odangowei & Okiemute, 2019). The preferred type

Fig. 17.3 Geophagic materials sold in an open market in Gaborone, Botswana

of soil eaten by Kenyan women according to Louba et al. (2004) was soft stone, known locally as *odowa* and earth from termite mounds.

In general, geophagy is more prevalent in Africans and people of African descent in the diaspora than in other population groups with a rate of 40% among women (George & Ndip, 2011). In some African countries (e.g. Botswana), soil-eating is stigmatized and as a consequence, geophagists are not open to the idea of sharing their experiences with the habit even though the topic is a cause for concern.

17.3 Biochemical Functions of Soil Ingestion

17.3.1 Absorption of Dietary and Bacterial Toxins

The ingestion of geophagic clays provides perks such as the absorption of dietary and bacterial toxins associated with gastrointestinal disturbances by the clay (Nkansah et al., 2016). Several studies have detailed the great work of probiotic microbes to avoid the progression of hurtful bacteria, boost the immune system and increase resistance to infection (Msibi, 2014). Some geophagists say they eat soil to moderate the destructive impacts of plant chemicals or organisms by adsorbing pathogens and poisons inside the intestine lumen or by coating the surface of the intestinal endothelium thereby making it less porous to poisons and pathogens (Young et al., 2010).

Adsorbent smectite clays have been illustrated to possibly shield the intestine from undesired chemicals as well as easing sicknesses such as esophagitis, gastritis and colitis (Odangowei & Okiemute, 2019). Clays were used to treat many forms of poisoning including mercury ingestion. The success of this treatment has been credited to the ion-exchange capacity of clay which portrays the mobility of components in clay (Ekosse & Jubman, 2010). These properties could be of major importance in influencing the ability of the clays to cover the gut wall thereby acting as a boundary to harmful chemicals and microorganisms and as a mucus secretion stimulant (Young et al., 2010).

17.3.2 Nutritional Benefits

Exposure to trace elements (iron (Fe), copper (Cu), zinc (Zn), rubidium (Rb), selenium (Se), strontium (Sr), molybdenum (Mo), manganese (Mn), lead (Pb), arsenic (As), chromium (Cr), cobalt (Co), vanadium (V) and cadmium (Cd)) as a result of geophagy has not been given significant consideration. However, it could be making critical contributions to the recommended dietary intake of different trace elements in the human diet (Ngole-jeme et al., 2016). Even though trace elements occur in diminutive amounts within the human body and other living beings, they perform a crucial part in maintaining health and well-being. Trace elements must be in small and well-regulated amounts to be useful. If the amount is below or over the ideal range, an element can become harmful (Hasan et al., 2021).

17.3.3 Treatment of Anaemia

The practice of Geophagy has been linked with anaemia for several centuries as confirmed by researchers and physicians (Ekosse & Jubman, 2010; Hooda et al. 2004). Research on the potential impact of soil ingestion on human mineral nutrition was done and tested the hypothesis that a large portion of mineral nutrients in geophagic materials are potentially available for absorption in the body and found out that despite the soils being rich in mineral nutrients, soil ingestion has the potential to limit the absorption of bioavailable nutrients, particularly micronutrients such as Fe, Cu and Zn (Hunter-Adams, 2016). A large number of reports of iron deficiency anaemia caused by impaired iron absorption from the gastrointestinal tract due to the ingestion of geophagic soils have been observed although on the contrary, iron deficiency may be the cause of geophagy (Abrahams, 2002).

A high possibility of anaemia due to malaria and the practice of geophagy being native have been associated with developing countries including Africa. When compared to those who did not ingest soil, women in Ghana, who ingested soil, were 1.23 times more likely to be anaemic (Intiful et al., 2016). Red soil is alleged to have properties that might inhibit iron deficiency anaemia even though iron bioavailability has been negated (Ekosse & Jubman, 2010). A study by Geissler et al. (1998) showed a significant negative association between geophagy and iron deficiency anaemia. Although the practice of geophagy is often associated with anaemia, it has not been scientifically established if people consume soils because of iron deficiency or if iron deficiency is the result of geophagy given that the bioavailability of iron in consumed geophagic materials is not guaranteed (Odongo, 2015).

17.3.4 Development and Growth of the Human Body and Stress Relief

Approximately 915,000 tons/year of water-soluble compounds of zinc is released by weathering (Sandstead, 2015). People who already have a low Zn intake worsen their deficiency condition by practising geophagy. This can be treated by oral Zn intake to ameliorate linear growth and sexual maturation (Abrahams, 2002). A study by Hooda et al. (2002) on the conceivable impact of geophagy on the bioavailability of Fe, Zn and Ca found that all the sampled geophagic materials absorbed large amounts of Fe and Zn regardless of the composition of the geophagic materials and under acidic conditions (pH ~ 2.0). However, the calcareous soil samples showed desorption of Ca at a significant rate. The study, therefore, concluded that whilst calcareous geophagic material might supplement Ca, it can cause the deficiency of Fe and Zn. In vitro digestion simulation experiments found that there is a possibility that geophagy might reduce the absorption of iron and zinc whilst increasing the supplementation of calcium (Henry & Cring, 2013).

Pregnant women who require extra calcium may be subject to geophagy as some clay has been confirmed to supplement calcium. Calcium is vital for the development of bones, particularly for foetuses (Odangowei & Okiemute, 2019). Hormones and a wide variety of enzymes involved in reproduction are sensitive to Zn as a microelement, and thus, zinc deficiency injuriously affects reproduction in females (Odongo, 2015). Geophagy may be a response to psychological distress and this association is more relevant to pregnant women since they use it to ease anxiety and/or stress. This was concluded from a study on pregnant women and it was found that there is a positive correlation between the amount and frequency of consumption and psychological distress (Yamamoto et al., 2019).

17.4 Potential Human Health Implications of Geophagia

17.4.1 Exposure to Potentially Toxic Elements

Even though there might be fulfilments and supposed benefits of geophagy, care should be taken as they have been reported to contain potentially toxic elements such as lead, mercury and cadmium and microbes present in the geophagic soils which can be dire to human health (Hunter-Adams, 2016). The adsorption of potentially toxic elements, including trace metals and heavy metals vary with age, gender, growth, body composition, genetics, pregnancy, lactation (Freeland et al., 2015). Contamination of soil by heavy metals in Africa has been widely reported (e.g. Eze et al., 2010, 2016a, b; Kebonye et al., 2017). Potentially harmful elements (PHE) are currently treated as the most active environmental pollutants, and their release has been observed to be increasing in the last decade. Metals released from various sources, natural and anthropic can be scattered into the environment and be taken up in plants and finally in the human body consequently causing severe health problems such as intoxication, neurological disturbances and cancer (Bini & Wahsha, 2014). Some metals are found naturally in the earth's crust and therefore contained in geophagic materials, which are ingested by humans in varying portions. Trace metals detected in soils at high levels have been involved in a significantly high number of disease conditions (Owumi & Oyelere, 2015).

According to Odangowei and Okiemute (2019), lead (Pb), calcium (C) and zinc (Zn) are present, especially in urban soils; therefore, children and other geophagy practitioners are vulnerable to poisoning from ingestion.

Acute poisoning of As symptoms is associated with the gastrointestinal tract which includes nausea, abdominal pain and diarrhoea. Cd is dire to human health because it can cause lung and kidney damage. The Agency of Toxic Substances Registry (TATSR) concluded that exposure to Cd can cause cancer in humans and disrupt the endocrine and has estrogenic properties (Egendorf et al., 2020). Research has shown that ingestion of geophagic clay does not contribute to risky mercury (Hg) and Cd intakes in grown-ups or new-borns. The hazard of pre-birth Cd introduction to foetuses is low because the metal is caught by the placenta tissues with exceptionally small amounts reaching the foetus (Kutalek et al., 2010).

Pb is a common and dangerous environmental toxicant, which initially came from smelting many years ago. Exposure to Pb in children affects the brain and nervous system development (Egendorf et al., 2020). Ingested soil can moreover be an imperative source of PHEs in geochemically atypical zones such as mineralised and mined locale. Contaminated levels of Uranium (U) and Thorium (Th) in soils overlying granite complexes have been reported in north-central Nigeria, where there are high levels of radiation in a region with the widespread practice of geophagy (Davies, 2013). Acute exposure to Pb can cause convulsions, coma and death where residual effects can be mental disability and behavioural disorders (Egendorf et al., 2020). IQ scores have reportedly dropped in children following exposure to lead in a total of 169 sites. The IQs were reduced in ranges from 4.94 to 14.96 that indicate a clear major cognitive impact (Fowler et al., 2015). Anaemia, renal failure, damage to the immune system and reproductive organs and toxicity to foetuses are possible Pb exposure even though there is no known safe level of Pb exposure (Egendorf et al., 2020; Hildebrand & Hallas, 2011; Owumi & Oyelere, 2015). Pb affects many organs, but the most significant effect is in the developing system (brains and nervous system) of children. (Hildebrand & Hallas, 2011; Abrahams, 2002) A study done in South Africa revealed that people who ingested soils (clays) may have higher Pb levels, but other analyses showed that the relationship was not statistically significant (Hunter-Adams, 2016). Recently, blood and urine samples of pregnant women who practised geophagy were found to have generally higher concentrations of trace metals than the samples of non-consumers in South Africa (Orisakwe et al., 2020).

The World Health Organisation (WHO) determined Pb as a chemical of major health concern amongst others. When calcium demands are high during pregnancy, Pb is circularised from the maternal bone into the blood. Pb also modifies bone formation when ingested (Hildebrand & Hallas, 2011). More studies are needed to examine the extent to which geophagy and the types of soil contribute to exposure to Pb, for example, maternal diet, calcium and iron status (Gundacker et al., 2017). The lack of food intake diaries and Total Diet Studies makes it inconvenient when attempting to evaluate the contribution of geophagy to the total Pb and Cd exposure to consumers (Orisakwe et al., 2020).

Pregnant women and children are more susceptible to Pb. They absorb 40% to 70% of ingested Pb with new-borns being of elevated risk as their blood lead levels generally surpass that of the mother due to simple diffusion and unidirectional passage of Pb past the placenta (Hildebrand & Hallas, 2011). Exposure to toxic metals by pregnant women should be of great concern because these metals can reach and cross the placental barrier thereby causing complications in placental transport systems (Orisakwe et al., 2020).

Soil ingestion should be taken into consideration in risk assessments concerning not only Lead but other PHEs such as arsenic and organic contaminants. Mercury (Hg) is another toxic element commonly found in geophagic materials. Mercury is found in three main chemical forms: Hg^0 (metallic), which is inhaled and absorbed to all major organs at a fast rate; 1-Hg (inorganic compounds), which accumulates mainly in the kidneys causing kidney damage; and meHg (organic compounds such as methyl mercury). Mercury may have potential permanent impacts on brain and nervous system development of foetuses and endocrine systems of children (Egendorf et al., 2020).

17.4.2 Gastrointestinal Disturbance

The accumulation of soil in the intestines can result in constipation, chronic abdominal pain and perforation of the colon (Abrahams, 2002). Woywodt and Kiss (1999) reported sigmoid colon perforation and fatal peritonitis caused by geophagy in a patient from South Arica. The patient also mentioned that they are constipated and experienced intense pain. Internal accumulation of soils in pregnant women in turn causing maternal deaths and complicated labour has been reported (Odangowei & Okiemute, 2019). The mineralogical composition of geophagic clays in Botswana and Swaziland is dominated by quartz, which could have dire effects such as intestinal blockage and irritation on the intestinal lining (Ekosse & Anyangwe, 2012; Ekosse & Ngole, 2012). Soils containing iron may contribute to the aggravation of the intestine lining resulting in gastrointestinal distress, such as cramping and clogging. However, iron overload in the body happens basically from genetic conditions or long-term consumption of iron-rich foods or supplements (Nyanza et al., 2014).

17.4.3 Pathogenic Organisms and Microbe Ingestion

There are millions of microbes found in soil which can be divided into five groups, namely: bacteria, viruses, algae, fungi and protozoa (Msibi, 2014; Mhete et al., 2020). These microbes could lead to infections in the gastrointestinal tract. Aerobic bacteria and fungi from geophagic soils in Africa have been found at high levels (Gundacker et al., 2017). Bacteria such as Clostridium perfringens, *Clostridium tetani and Clostridium botulinum* may also be found in geophagic soils. These bacteria are causative agents of gas gangrene, tetanus and botulism and other human pathogens (Obi & Ekosse, 2010). Microbiological analysis of geophagic materials in Central, West and East Africa found that some samples would be rejected if inspected as foodstuff due to microbial contamination being high more so in unheated material. FAO does not have limits for fungal contamination, particularly mould; however; the German Society for Hygiene and Microbiology (DGHM) states that mould contamination is acceptable up to 10, 000 cfu/g for instant products (Kutalek et al., 2010). Table 17.1 shows the groups of bacteria and fungi found in geophagic samples from Central, West and East Africa.

Table 17.1 Groups of bacteria and fungi found in geophagic samples from Central, West and East Africa

Groups of bacteria	Groups of fungi
Bacillus spp.	*Penicillium* spp.
Corynebacterium spp.	*Aspergillus* spp.
Coagulase negative staphylococci	*Cladosporium* spp.
Micrococcus spp.	*Streptomyces* spp.
Acinetobacter spp.	*Acremonium* spp.
Enterobacteriaceae spp.	*Paecilomyces* spp.
Pseudomonas spp.	*Rhizopus spp*
	Nigrospora spp.
	Scedosporium spp.
	Candida spp.

Kutalek et al. (2010)

Consumption of soil can also cause the transmission of geohelminths, a group of intestinal parasites. The risk of geohelminth infection has been linked to open defecation (Ravuluvulu, 2018). Geophagic soils are contaminated by animal or human faeces and agricultural practices; more specifically, parasite eggs such as roundworms can stay torpid for years (Davies, 2013; Sumbele et al., 2014); therefore, eggs of parasite worms (geohelminths) in geophagic soils can be consumed together with those soils and have dire consequences on the consumer (Abrahams, 2002). Geophagy is an imperative hazard factor for ingested nematode infections in African children (Glickman et al., 1999).

Geohelminth infections associated with Geophagy cause 135,000 deaths in the year annually (WHO, 2002). An estimated two billion people are infected with geohelminths every year (Msibi, 2014). In Africa, geohelminths are the second most cause of death for children under the age of six (Ravuluvulu, 2018). Geophageous children's exposure to intestinal *Ascaris lumbricoides* (roundworm) and *Trichuris trichiura* (whipworm) contamination has been quantified by research conducted in Kenya (Abrahams, 2002). A study conducted in Western Kenya found that pregnant and lactating women had a great risk of infection with *Ascaris* due to geophagy (Odongo, 2015). The infection from parasites due to ingesting soils contaminated with them can cause deficiency complications. Soil ingestion can also lead to toxocariasis through the ingestion of *Toxocara canis* (the common dog roundworm) or *T. cati* (cat roundworm) eggs (Table 17.2) (Abrahams, 2002). STH infections do not usually end in clinical disease because the pathology of STH infections is intensely linked to the worm count. Therefore, it has been noted that hosts normally have a few worms; hence, they are not showing or having any signs or symptoms (Odongo, 2015).

Few studies have connected geohelminth infection with soil consumption; however, geohelminth disease was connected to iron deficiency among HIV patients. Some parasitological studies conducted in Zambia revealed that the soil ingested by geophagous pregnant ladies did not contain helminth ova probably because some geophagists heat the soil before consumption, which may render it safe for consumption (Odongo, 2015). In conventional societies, there is a broad hone to heat-treat (bake) the soil before consumption, and this tends to relieve the dangers to some degree (Kawai et al., 2009).

Table 17.2 Effects of parasitic worms on the human body when ingested according to Abrahams (2002)

Parasitic worm	Effect
Ascaris lumbricoides	Scariasis: Abdominal pains
Trichuris trichiura	Trichiuriasis: Complications in the alimentary tract
Toxocara canis(common dog roundworm) or *Toxocara catu* (cat roundworm)	Toxocariasis: Visceral larva migrans (VLM) and ocular larva migrans (OLM) characterised by aggravation, eosinophilic granulomas and blindness. (After ingestion, the larvae are carried by the circulation system into distinctive tissues and organs of the body)

17.5 Indices for Assessing of Potential Health Risks of Geophagic Soils

Risk assessment of contaminants is vital because the accumulation of the effects (some of which are not apparent and/or instant) of potentially toxic elements as time goes could prove too late for any effective medical attention. Paracelcus (1493–1541 BC) described the principle of toxicity as that 'all substances are poisonous there is none which is not a poison; the right dose differentiates a poison from remedy'. Therefore, the amount of intake of elements defines the toxicity, for instance, essential elements can be toxic to human health when taken in high dosages. Therefore, given that soil ingestion could pose adverse health risks to consumers, some indices have been developed for the risk assessment at different quarters. Health risk evaluation is vital to understand the likelihood of incidence of any given plausible magnitude of adverse health effects over a given period (Naveedullah et al., 2014). Some of the indices used by researchers include carcinogenic risk (R), hazard quotient (HQ) and hazard index (HI).

17.5.1 Carcinogenic and Non-carcinogenic Risks

Cancer researchers believe that our environment including air, water, soil and anything that humans interact with has the potential to be a major contributor to cancer development. About 530, 000 new cases of cancer occur annually according to 2002 estimates of cancer in Sub-Saharan Africa (251, 000 in males and 279, 000 in females). The most common types of cancer are Kaposi's Sarcoma (KS), liver cancer, prostate cancer, cervical cancer and breast cancer (Davies, 2013). Trace metals such as As, Cd, Pb, Ni and Cr have been considered carcinogenic by the International Agency for Research on Cancer (IARC) (Karimian, et al., 2021). These trace metals, found in soil, drinking water and air, have been linked with the geo-environmental risk factor for cancer in Africa because exposure levels to them are significantly high but possible to be altered (Davies, 2013).

Cancer risk is defined as the likelihood of an individual's health risk from carcinogens in a lifetime. It is vital to calculate the cancer risk value to determine if there is a chance of being exposed to carcinogens (Nkansah et al., 2016). Most studies on the health risks of the practice of geophagy have indicated the concentrations of trace elements and their health implications according to World Health Organisation (WHO) standards, but do not examine the carcinogenic and non-carcinogenic risk to humans.

A few studies have evaluated the carcinogenic and non-carcinogenic health risks of trace metals in geophagic soils through oral ingestion, inhalation and dermal absorption. The computation of carcinogenic and non-carcinogenic health risks is based on the guidelines provided by the United States Environmental Protection Agency (USEPA). USEPA regards R values ranging from 10^{-6} (1 in 1, 000, 000) to 10^{-4} (1 in 10,000) to be in the acceptable predicted lifetime risks for carcinogens (USEPA, 2011). A study in Nigeria conducted by Orisakwe et al. (2020) concluded that the R values obtained from geophagic samples were high (0.17–0.33 (x 10^{-4}) and 4.56–9.12 (x 10^{-4}) when taking into consideration the cumulative exposure from different pathways of exposure and sources of these carcinogens. Cancer Risk is computed as:

$$\text{Cancer Risk}\left(\text{R}\right) = \text{CDI}^{*}\text{SF}$$

where CDI is the chronic daily intake of carcinogens (mg kg^{-1} d^{-1}) and SF is the slope factor of hazardous substances (mg kg^{-1} d^{-1}).

17.5.2 Hazard Quotient (HQ)/Non-carcinogenic Effect

HQ (primarily used by USEPA to assess health risks of air toxics) is the ratio of being exposed to hazardous substances to the chronic reference dose (RFD) of a toxic substance (mg kg^{-1} d^{-1}). An HQ less than one (HQ < 1) means the exposure is unlikely to result in obvious adverse effects, whereas an HQ above one (HQ > 1) means there is a high risk of carcinogenic effects to exposed subjects (Nkansah et al., 2016). HQ values for Pb in geophagic materials in a region in Nigeria were found to be above one, which means most of the geophagic materials are deemed unsafe for consumption for both children and adults (Orisakwe et al., 2020). The Hazard index (HI), developed by USEPA in 2002, is the sum of hazard quotients that affect the same target organ or organ system. HQ and HI values are computed with the following equations:

$$\text{HQ} = \text{CDI} / \text{RFD}; \text{and}$$

$$\text{HI} = \sum \text{HQ}$$

where HQ is the Hazard Quotient, CDI is the Chronic Daily Intake of the potentially harmful element (PHE), and RFD is Chronic Reference Dose.

A few studies have examined trace element exposure risk and hazard quotient (trace element exposure chance of a component in a test) related to geophagic soils (Ngole-jeme et al., 2016). Kamunda et al. (2016) found HQ values of toxic elements including As and Chromium (Cr) to be greater than acceptable in geophagic soils from South Africa.

Table 17.3 Estimated standard PMTDI values of heavy metals in 70 g of clay

Heavy metals	WHO/FAO PMTDI (μg/BW/day)	PMTDI for 60 kg BW (μg/day)
As	3.0	180
Pb	3.0	180
Hg	0.6	36
Cd	0.3	48

WHO (2011)

17.5.3 Permissible Maximum Tolerable Daily Intake (PMTDI)

PMTDI is used to monitor and control the accumulation of contaminants in the body. See Table 17.3 for some estimated standard PMTDI values. A study done by Nkansah et al. in 2016 found that the levels of potentially toxic elements in a few of the geophagic clays expended by local people in Kumasi, Ghana, were over the limit of the PMTDI. World Health Organisation (WHO) recommended that ingestion of geophagic clays that contain heavy metals could cause cancer.

17.5.4 Bio-accessibility

The environmental risk of the consumption of metals by humans through the soil and contaminated food is evaluated by measuring their bio-accessibility. Bio-accessibility is the portion of a compound that is released into the gastrointestinal tract from its matrix and thus becomes available for intestinal absorption and enters the bloodstream (Intawongse and Dean, 2006). A lot of published studies on the chemical properties of geophagic earth are not very helpful for testing the nutritional theorem because they are limited to the content of elements in total and not the bioavailability of these elements (e.g. Orisakwe et al., 2020; Ekosse & Jumbam, 2010; Oyebanjo et al., 2020).

The simulation of the release of heavy metals process in the gastrointestinal tract by the use of several in vitro methods has been developed to determine the bioaccessibility of a toxicant. Extractant solutions are used to make a digestion simulation in the stomach and small intestine. Various in vitro methods developed to simulate the outcomes of the human-digestion process have been described in the scientific literature: physiologically based extraction tests (PBET) and generally named simulated gastrointestinal extraction procedures (Intawongse & Dean, 2006).

Soil texture, the chemical form in which an element is present in soils, and the chemical environment inside the gastrointestinal tract influence the bio-accessibility of elements in geophagic soils. Studies show that the bio-accessibility of Pb in soils ingested by humans may be up to 83% (Ngole-Jeme et al., 2016). Pb should be interpreted carefully during risk assessment because it is one of the least bioavailable metals; hence, it is bio-accessible in fractions (Kutalek et al., 2010). The type of soils ingested changes from one locale to the other in terms of their properties, and subsequently, the bio-accessibility of trace elements in these soils may too vary (Ngole-Jeme et al., 2016). In vitro, PBET has been used to simulate the human gastrointestinal tract, and it showed that geophagists can be supplied significant amounts of some mineral nutrients, particularly Fe (Abrahams et al., 2006).

Mathematically, metal bio-accessibility is calculated as follows:

$$\text{Bioaccessibility},\% = \frac{\text{Concentration in extract, g / L)} \times \text{vol of extract, L}}{\text{Concentration in soil, mg / kg} \times \text{mass of soil used, g}} \times 100$$

17.6 Conclusion

Appropriate nutrition is a crucial part of the health and development of people, especially pregnant women and children. With regards to the United Nations Sustainable Development Goals, this review chapter has discussed geophagy and the possible outcomes of the practice on human nutrition and health. The discourse around this topic may help with the reduction of deaths and illnesses caused by contamination and pollution of air, water and soil by potentially toxic elements. The practice of geophagy according to available research is more popular in Africa and among people of African descent living outside of Africa. This may be because of its cultural significance. In as much as there are benefits to soil ingestion, the health risks of the practice outweigh the benefits. For instance, soils can supplement essential nutrients such as Fe, Mg, Ca and Fe. Additionally, they can reduce the absorption of bioavailable nutrients. Other adverse effects include infections from microbes and pathogens in the soil and gastrointestinal disturbance. To assess the health risk of soil ingestion, indices such as hazard index (HI) and hazard quotient (HQ) may be very useful. Instead of ingesting soil, it would be advisable to rather have a supplementation for mineral nutrients that do not have high health risk effects. It would also be advisable to educate geophagists about the practice as it has been shown to reduce intake by a significant rate and report cases of geophagy in hospitals and clinics to have a more accurate idea of the extent of the practice. Governments, especially in geophagy-prevalent countries, should put in measures to try to reduce the practice of geophagy by prohibiting suggestions of the health benefits of geophagic materials, more so from marketers.

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Chapter 18
Spatial Analysis of Breastfeeding Practices and Childhood Morbidity Episodes in Ghana: A Cross-sectional Study of a National Dataset

Anthony Mwinilanaa Tampah-Naah, Adams Osman, and Joseph Nyaaba Akongbangre

18.1 Introduction

Appropriate breastfeeding practices play an integral role in sustaining the healthy growth and development of children worldwide. However, in situations where mothers or caregivers do not adhere to best practices of feeding infants and young children with optimum breast milk and appropriate complementary foods or fluids, the prevalence of childhood morbidities such as diarrhoea, acute respiratory infection (ARI), anaemia, and fever may be high. Evidence suggests that breastfeeding practices, undoubtedly, correlate with infants' and young children's health outcomes (Marques et al., 2014). In Ghana, child health is a major public health issue (Ministry of Health [MOH], 2007). To address challenges associated with child health, a strategy (2007–2015) was formulated and implemented with the aim of achieving the past Millennium Development Goal (MDG) 4 – to reduce by two-thirds the under-five mortality rate. Most countries including Ghana, however, did not meet this target. Consequently, this has been re-packaged into Sustainable Development Goal (SDG) 3 (target 2) – to reduce 'under-5 mortality to at least as low as 25 per 1000 live births' (United Nations [UN], 2016, p.1).

An assessment of survey reports of Ghana indicates that the prevalence of diarrhoea in 2008 was 19.8% and dropped to 12% in 2014. Likewise, ARI prevalence in

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2008 was 5.5% and reduced to 3.6% in 2014. Also, the prevalence of anaemia in 2003 was 77.9% and reduced to 65.7% in 2014. Furthermore, the prevalence of fever in 2008 was 20% and this reduced to 14% in 2014 (Ghana Statistical Service, Ministry of Health & Inner-City Fund Macro [GSS, GHS & ICF International], 2009, 2015). In relation to breastfeeding practices, the exclusive breastfeeding (0–5 months) rate was 63% in 2009 and this reduced to 54% in 2015 (GSS, GHS & ICF International, 2009, 2015). Again, 68% of breastfeeding children received solid or semi-solid foods in 2009 and this increased to 88% of breastfed children (6–23 months) in 2014 (GSS, GHS & ICF International, 2009, 2015). While the aforementioned evidence suggests some changes in rates, a drastic reduction in the prevalence of childhood morbidities, and improvements in breastfeeding practices, indicators among children under 2 years of age in Ghana would be needed to meet the related targets of SDG 3.

Notwithstanding the contributions made by studies (Ewusie, Ahiadeke, Beyene & Hamid, 2014; Nonvignon, Aikins, Chinbuah, Abbey, Gyapong, Garshong, et al., 2010) to the child health and nutrition literature, less attention has been paid to breastfeeding practices of mothers, which is a key variable in early childhood infections pathways. Yet, breastfeeding practices of children are pre-requisites to their positive growth and development, health, and survival (WHO, 2021). Furthermore, studies that rigorously explored district spatial patterns and hot spots of breastfeeding practices and related morbidities in Ghana are rare, if not available. The novelty of this study, hence, hinges on its ability to concurrently appraise the hot spots of breastfeeding practices and childhood morbidity and to further assess potential risk factors in Ghana. Findings from this study would be relevant to designing and implementing child health interventions in the country.

18.2 Methods

18.2.1 Study Setting

The study setting consists of all the ten regions of Ghana (Fig. 18.1). The population of the country, as recorded in the 2021 Population and Housing Census Report, was 30,832,019 million people with an average annual growth rate of about 2.1 per cent. Greater Accra Region had the highest population of 5446, inhabitants and Ahafo Region (originally part of Brong Ahafo Region) had the least population size of 702,110. Still, Greater Accra is the most densely populated region with about 1678.3 people per square kilometre (GSS, 2021). In general, the southern part (forest area) of the country had the higher population density compared to the northern part (savanna zone).

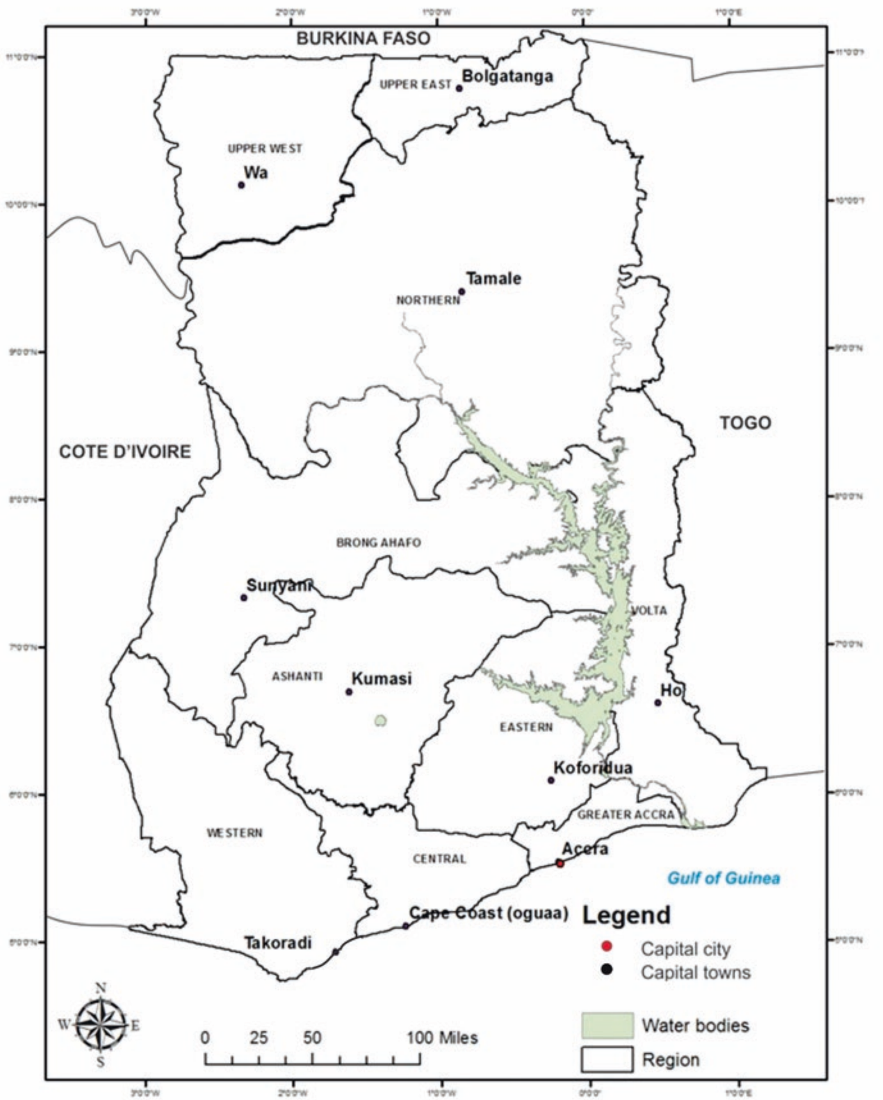

Fig. 18.1 Map of Ghana showing regional boundaries

18.2.2 Research Design

The present study applied a cross-sectional design as a way of collecting, analysing, and presenting data to better answer the research questions. Specifically, the data was used for two purposes. One, GPS coordinates were used to analyse spatial patterns and hot spots of breastfeeding practices and childhood morbidity. And second, it was used to conduct multivariate logistic regression analyses with explanatory, exposure, and outcome variables.

18.2.3 Data Sources

Quantitative data were obtained from GDHS 2014. The specific data used in this study was the GDHS 2014 individual dataset. This dataset contains details on but is not limited to mothers' characteristics, breastfeeding practices, and childhood morbidity (diarrhoea, ARI, anaemia, fever). In addition, Geographical Positioning System (GPS) coordinates were part of the data. Demographic and Health Surveys (DHS) have regularly chronicled the geographical location of each cluster of surveyed households with handheld GPS units. Data are captured at an aggregated level to protect the actual identity and location of respondents. However, these data at the cluster level permit linkages between GDHS data on infant and child morbidity and information from other data sets. Detailed information on the data is at https://dhsprogram.com/methodology/survey/survey-display-437.cfm

18.2.4 Data Management

To validate the data, the breastfeeding status of children (0–23 months) was recalculated. The recalculation reflected figures in the GDHS 2014 report (on page 161– https://dhsprogram.com/publications/publication-FR307-DHS-Final-Reports.cfm). Issues captured under this section are: no breastfeeding; exclusive breastfeeding; breastfeeding and consuming plain water only; breastfeeding and consuming non-milk liquids; breastfeeding and consuming other milk; and breastfeeding and consuming complementary foods. These categories are hierarchical and mutually exclusive.

18.2.5 Outcome Variable

The study considered four outcome variables (diarrhoea, ARI, anaemia, and fever). These are among the top contributing to childhood morbidity in the country (GSS, GHS, ICF Macro, 2015). In the GDHS 2014, data on 'all diarrhoea' and 'diarrhoea with blood' were collected. Mothers were asked, 'Whether any of their children under five years of age had diarrhoea during the two weeks preceding the survey'. The responses to this question were: *No = 0*; *Yes (last two weeks) = 1*; *Don't know = 8*. Similarly, the prevalence of ARI was estimated by asking mothers 'Whether their children under age five had been ill with a cough accompanied by short rapid breathing in the two weeks preceding the survey. 'Cough' was used as a proxy to determine ARI among children'. The ARI categories were: *No=0*; *Yes=1*; *Don't know=8*. For anaemia, 'children who stayed in the household on the night before the interview' were tested for anaemia based on their haemoglobin levels. The categories for this variable were: *Severe = 1; Moderate = 2; Mild = 3; Not anaemic = 4*. The various types of anaemia were characterized by haemoglobin levels as follows; severe (less than 7.0 g/dl); moderate (7.0–9.9 g/dl) and mild (10.0–10.9 g/dl). These were recoded as *Anaemic (severe, moderate, mild) = 1; and not anaemic = 2*. Likewise, mothers were asked 'Has (NAME) been ill with a fever at any time in the last 2 weeks?' with responses *Yes = 1*, *No = 2*, and *don't know = 8*. Only the *Yes = 1* and *No = 2* responses were considered for the analysis. Thus, all the '*Don't Know*' responses of the dependent variables were excluded from the analysis.

18.2.6 Exposure Variable

The exposure variable was breastfeeding (practices). This variable has six categories as captured in the GDHS 2014 report consisting: no breastfeeding, exclusive breastfeeding, breastfeeding plus water only, breastfeeding plus non-milk liquids, breastfeeding plus other milk, and breastfeeding plus complementary foods. These were determined by asking mothers about the breastfeeding status of a child (0–23 months) within a recall period of 24 h (yesterday and last night). For the sake of comparison, the exposure variable was recoded to conform to most related literature. This variable was, hence, recoded into four categories as follows: not breastfeeding, exclusive breastfeeding, predominant breastfeeding, and partial breastfeeding. Not breastfeeding denotes that an infant or child was not fed with breast milk but with other foods. Exclusive breastfeeding defines an infant or child breastfed with only breast milk. Predominant breastfeeding means an infant or child who was breastfed and given water and non-milk liquids. Partial breastfeeding refers to an infant or child being fed breast milk along with other milk, and complementary foods. The aforementioned categorizations are in accordance with WHO (2002) standard definitions.

18.2.7 Explanatory Variables

The explanatory variables selected for this study were informed by the review of related literature, and these variables are found in the GDHS. Some of the selected variables were recoded, while others were adopted as reported in the GDHS 2014 report. The selected variables consist of sex of child, marital status of mothers, education, wealth quintile, residence, and source of drinking water. See Table 18.1 for the categories of each variable.

Table 18.1 Spatial autocorrelation (Global Moran's *I*) of breastfeeding practices

Variable	Moran's Index	Expected Index	Variance	z-score	*p*-value
Morbidity					
Not breastfeeding	0.099038	−0.004651	0.000692	3.940287	0.000081
Exclusive	0.121369	−0.004651	0.000734	4.651563	0.000003
Predominant	0.113792	−0.004651	0.000722	4.406906	0.000010
Partial	0.047261	−0.004651	0.000716	1.940521	0.052316
Morbidity					
Diarrhoea	0.096479	−0.004651	0.000728	3.748256	0.000178
ARI	0.072805	−0.004651	0.000726	2.874740	0.004044
Anaemia	0.056534	−0.004651	0.000737	2.253649	0.024218
Fever	0.028028	−0.004651	0.000724	1.214795	0.224444

18.2.8 Management of Spatial Data

In relation to the spatial data, cartographic display of 216 districts' polygons was generated by extracting the coordinates of digitized boundary map into a National Grid, Ghana Metre-Grid Universal Transverse Mercator (UTM) coordinates system using ArcGIS version 10.3. The prevalence of breastfeeding practices (not breastfeeding, exclusive breastfeeding, predominant breastfeeding, and partial breastfeeding) and childhood morbidity (diarrhoea, ARI, anaemia, and fever) were estimated using reported frequencies in each survey cluster in the GDHS 2014. The breastfeeding practices and childhood morbidity frequencies were geo-coded to the district polygon layers to create geo-relational database for the spatial analysis. Initially, data on the prevalence of breastfeeding practices and childhood morbidity were extracted from GDHS using Stata version 18. These were exported to Microsoft (MS) Excel sheets for further sorting. The MS Excel sheets containing the data were then loaded onto ArcGIS 10.1 to join them with the GPS cluster coordinates obtained during GDHS 2014.

18.2.9 Selections of Respondents

The criterion for selecting respondents was that mothers (15–49 years) should have been living with their youngest child under 2 years of age (0–23 months) at the time of the survey. Appropriate STATA commands were used to obtain a weighted sample size of 2022 mother-child pairs.

18.2.10 Data Analyses

Three statistical tools were applied to spatially analyse the data on breastfeeding practices and childhood morbidity. These tools were: spatial autocorrelation (Global Moran's *I*), cluster and outlier analysis (Anselin's local Moran's *I*), and hot spot analysis (Getis-Ord G). Spatial autocorrelation was used to examine whether breastfeeding practices (not breastfeeding, exclusive, predominant, and partial) or childhood morbidity (diarrhoea, ARI, anaemia, and fever) had a clustering or dispersion pattern in the country using districts as features. To locate where breastfeeding practices or childhood morbidity were clustered, the ArcGIS clusters and outlier analysis tool were applied.

With breastfeeding practices, the following categorization was applied: (i) high-high cluster (districts showing high levels of breastfeeding practices surrounded by districts with similar high levels), (ii) low-low cluster (districts showing low levels of breastfeeding practices surrounded by districts with similarly low levels), (iii) low-high cluster (districts showing low levels of breastfeeding practices surrounded by district with similar higher values), and (iv) high-low cluster (districts showing comparatively high levels of breastfeeding practices surrounded by districts with similar lower values). Also, with childhood morbidity, the following groupings were used: (i) high-high cluster (districts showing high levels of morbidity surrounded by districts with similarly high levels), (ii) low-low cluster (districts showing low levels of morbidity surrounded by districts with similarly low levels), (iii) low-high cluster (districts showing low levels of morbidity surrounded by district with similar higher values), and (iv) high-low cluster (districts showing comparatively high levels of morbidity surrounded by districts with similar lower values).

The second part of the geospatial analysis was to examine hot spots. Hot spot analysis was, therefore, used to define districts with high prevalence versus districts with a low prevalence of the phenomena under study (breastfeeding practices and childhood morbidity), for instance, to identify districts that had a high or low rate of not breastfeeding children and to identify which districts have a high or low prevalence of diarrhoea. The description of a district as being a hot spot of a phenomenon was expressed in terms of statistical confidence. In the hot spot analysis, areas were indicated using a 95% confidence level.

Further multivariate analysis was done to determine which breastfeeding groups of mother-child dyads were significant predictors of childhood morbidities. The analysis was restricted to all youngest children under age two living with their mothers. All the outcome variables (diarrhoea, ARI, anaemia, and fever) were dichotomized, with *No = 0* and *Yes = 1* format. The exposure variable, breastfeeding practice(s) (hierarchically and mutually exclusive), was coded as: *not breastfeeding = 0, exclusive breastfeeding = 1, predominant breastfeeding = 2,* and *partial breastfeeding = 3*. The explanatory variables were arbitrarily assigned numeric codes starting with either *'0' or '1'*. In all the analytical procedures, appropriate sample weights were applied to ensure the generalization of the findings. And a $p < 0.05$ was used to examine associations of the independent and dependent variables. Using a multilevel modelling approach, logistic regression analyses were performed to assess the effect of explanatory variables that were considered as potential confounders on the association between breastfeeding practices and childhood morbidity. STATA version 13 was used for the multivariate analysis.

18.3 Results

18.3.1 Spatial Autocorrelation of Breastfeeding Practices and Childhood Morbidity

The results indicate a positive spatial autocorrelation for breastfeeding practices in the country. It was found that no breastfeeding (Moran's I = 0.099; p = 0.000), exclusive breastfeeding (Moran's I = 0.121; p = 0.000), and predominant breastfeeding (Moran's I = 0.114; p = 0.000) had clustering of similar values. This means that there is less than 1% likelihood that these clustered patterns could be the result of random chances (Table 18.1). On partial breastfeeding, given a Moran's I of 0.047 (p = 0.052), there is less than 10% odds that the clustered pattern could be a result of random chance.

Also, this study revealed positive spatial autocorrelation for childhood morbidity in the country. There were clustering of similar values for diarrhoea (Moran's I = 0.096; p = 0.000), and ARI (Moran's I = 0.073; p = 0.004), suggesting that there is less than 1% possibility that these clustered patterns could be the result of random chance (Table 18.1). With anaemia, given a Moran's I of 0.057 (p = 0.024), there is less than 5% likelihood that this clustered pattern could be the result of random chance. On fever, given the Moran's I of 0.028 (p = 0.224), the pattern does not appear to be significantly different than random.

18.3.2 Spatial Cluster Analysis of Breastfeeding Practices

Spatial clusters of breastfeeding practices (no breastfeeding, exclusive, predominant, and partial) were identified in the country. In each region, districts were used as the main elements for the identifications. Clusters were labelled as: not significant, high-high cluster, high-low outlier, low-high outlier, and low-low cluster. Each map (A to D) in Fig. 18.2 represents a type of breastfeeding practice, showing locations of identified clusters.

Figure 18.2, Map A, shows nine districts with high levels of not breastfeeding practice. Seven of these districts were in Greater Accra Region. Also, four districts (two in Brong Ahafo and one each in Ashanti and Volta) showed comparatively high levels of no breastfeeding practice. Also, 14 districts showed high levels of exclusive breastfeeding practice in Map B; seven in Upper West and six in Upper East

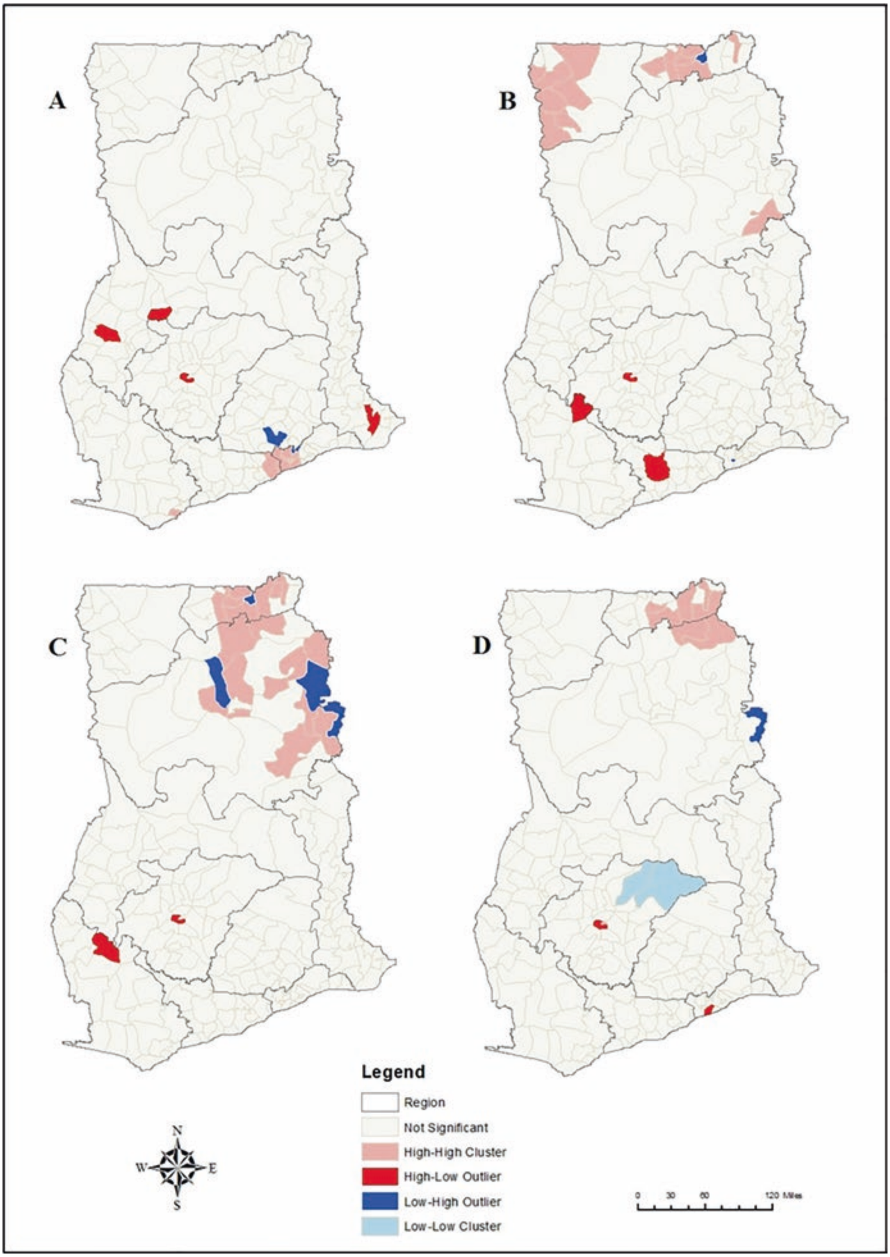

Fig. 18.2 Spatial cluster analysis (Local Moran I) of breastfeeding practices. (**A**) Not breastfeeding; (**B**) exclusive breastfeeding; (**C**) predominant breastfeeding; (**D**) partial breastfeeding

regions. Three districts (each found in Ashanti, Western, and Central) showed comparatively high levels of exclusive breastfeeding practice. Clustering of predominant breastfeeding revealed that 17 districts had high levels of predominant breastfeeding practice. Out of these districts, nine were in the Northern and eight were in the Upper East regions. Two districts (one each in Ashanti and Western) showed comparatively high levels of predominant breastfeeding practice. With partial breastfeeding, eight districts showed high levels in Map D; and five of them were in Upper East Region. Two districts (one in Ashanti and the other in Greater Accra) showed comparatively high levels of partial breastfeeding practices.

18.3.3 Spatial Cluster Analysis of Childhood Morbidity

Childhood morbidity (diarrhoea, ARI, anaemia, and fever) clusters were identified in the country. The clustering of districts was also classified as not significant, high-high cluster, high-low outlier, low-high outlier, and low-low cluster. Figure 18.3 displays the results of spatial cluster analysis of childhood morbidity (Maps A to D).

In Fig. 18.3, 16 districts in Map A were found to have highly clustered levels of diarrhoea cases. Half of the highly clustered districts were found in Upper East Region. The rest of the highly clustered districts were found in Upper West (3), Northern (4), and Brong Ahafo (1) regions. Also, three districts showed comparatively high levels of episodes of diarrhoea. Map B displays 14 districts identified with high clustered cases of ARI: five of them in central, four in upper east, two in Greater Accra, and one in eastern. Three districts (one each in Brong Ahafo, Ashanti, and Volta) showed comparatively higher cases of ARI. With anaemia, in Map C, it was found that seven districts showed high cases of anaemia. Four of the districts were in Northern, two in Upper East, and one in Greater Accra regions. Five districts (two in Brong Ahafo and one each in Ashanti, Western, and Volta) showed comparatively high levels of anaemia. Also, in Map D, 11 districts displayed high cases of fever; four districts each were found in northern; and upper west; two in upper east; and one in Brong Ahafo. Five districts showed relatively high cases of fever.

18.3.4 Hot Spots of Breastfeeding Practices and Childhood Morbidity

Prior to the data analysis, significant hot spots of breastfeeding practices were examined using 95% confidence intervals (CI). Colours that were used to indicate hot spots were: pink for not breastfeeding, yellow for exclusive breastfeeding, red for predominant breastfeeding, and green for partial breastfeeding. Also, hot spots of childhood morbidity were assessed with confidence intervals of 99%, 95%, and 90% (Fig. 18.4).

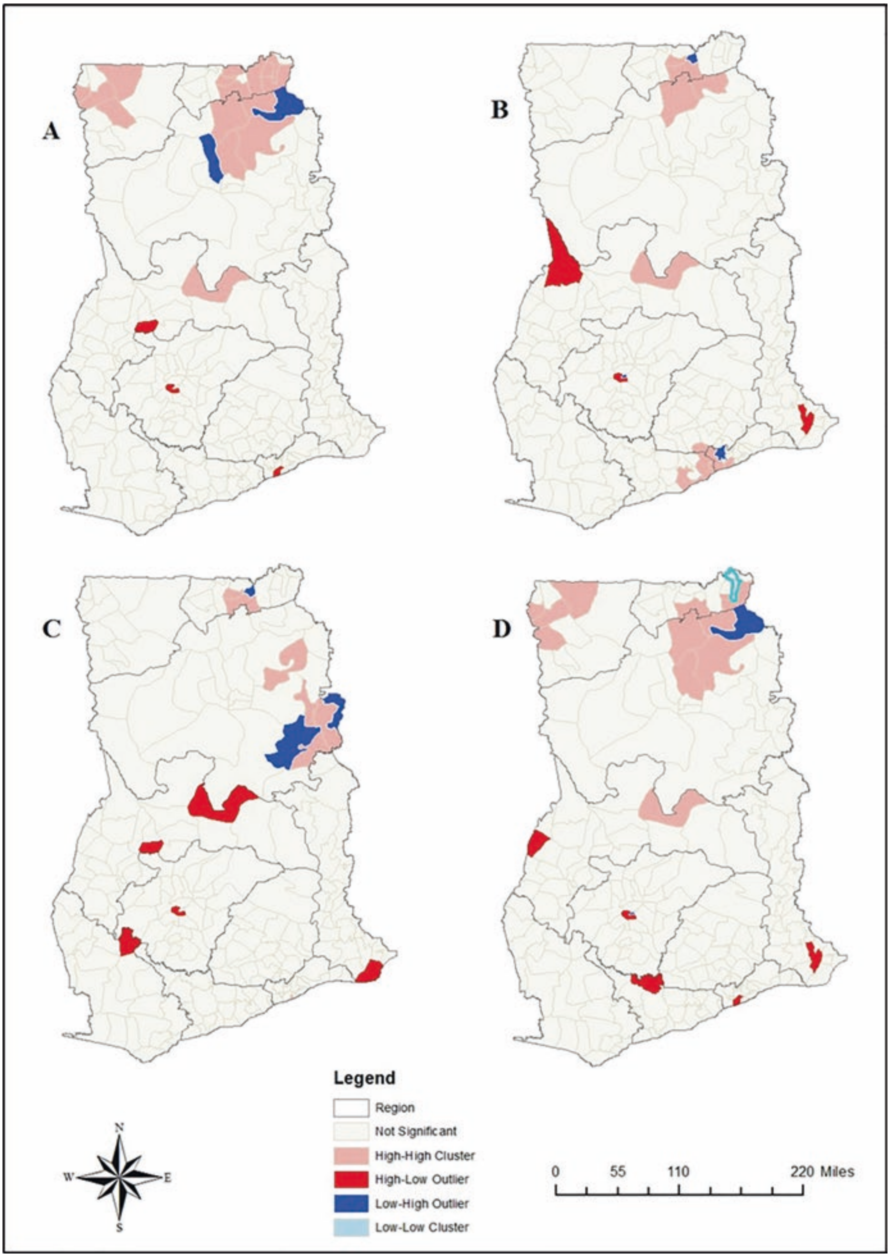

Fig. 18.3 Spatial cluster analysis (Local Moran *I*) of childhood morbidity. (**A**) Diarrhoea; (**B**) acute respiratory infection; (**C**) anaemia; (**D**) fever

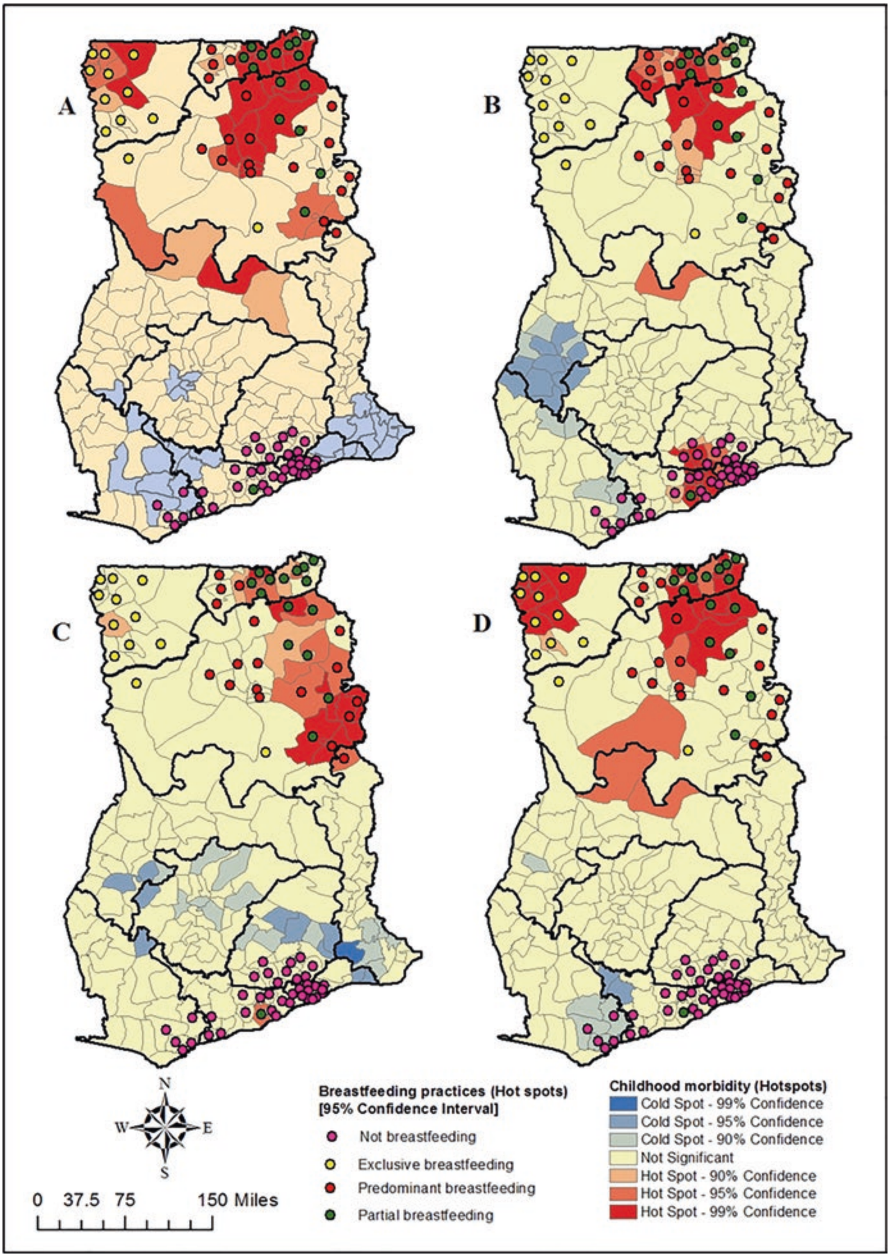

Fig. 18.4 Hot spots of breastfeeding practices and childhood morbidity. (**A**) Diarrhoea; (**B**) acute respiratory infection; (**C**) anaemia; (**D**) fever

In Fig. 18.4, on Map A, it was found that 19 districts (99% CI), eight districts (95% CI), and one district (90% CI) were significant hot spots of diarrhoea. In Map B, it was found that 19 districts (99% CI), eight districts (95% CI), and one district (90% CI) were found to be significant ARI hot spots. Map C shows that eight districts (99% CI), nine districts (95% CI), and one district (90% CI) were hot spots for the high prevalence of childhood anaemia. Map D revealed that seventeen districts (99% CI), four districts (95% CI), and two districts (90% CI) were significant hot spots linked with high episodes of fever. Overlaying the prevalence of breastfeeding practices on each map (A-D) for childhood morbidity, 31 districts (95% CI) were found to be significant hot spots where children were not breastfeeding. Also, with exclusive breastfeeding (Map B), 28 districts (95% CI) were found to be significant hot spots. It was further found that 31 districts (95% CI) in Map C were significant hot spots for predominant breastfeeding. Map D indicates that 13 districts (95% CI) were significant hot spots where children were partially breastfeeding.

18.3.5 Association Between Breastfeeding and Childhood Morbidity with Covariates

Mothers who were not breastfeeding (OR = 2.88, 95% CI = 1.63, 5.07), predominant breastfeeding (OR = 3.19, 95% CI = 1.84, 5.52), and partial breastfeeding (OR = 3.15, 95% CI = 1.98, 5.00) were about three times more likely to have children with diarrhoea compared to mothers who practiced exclusive breastfeeding (reference group) (Table 18.2). The odds of diarrhoea cases were similar in Model 1 after controlling for other variables. Children with optimum birth intervals (OR = 1.42, 95% CI = 1.04, 1.93) were slightly more likely to have diarrhoea compared to those with small birth intervals. It was intriguing to observe that children in houses with unimproved floors (OR = 0.62, 95% CI = 0.42–0.89) had a lower likelihood of being reported with diarrhoea compared to those with improved floors. Also, children whose mothers used other than gas or electricity for cooking had more than a threefold possibility of experiencing diarrhoea.

In relation to ARI, significant associations were found between breastfeeding practices. Compared with the reference group, children who were not (OR = 3.56, 95% CI = 2.05, 6.17), predominantly (OR = 2.76, 95% CI = 1.57, 4.82), and partially (OR = 3.20, 95% CI = 2.01, 5.09) breastfeeding were much more prone to having diarrhoea episodes (Table 18.2). In the multivariate model, the age of a child, and the number of antenatal visits was equally associated with ARI. Children aged 6–11 months (OR = 1.68, 95% CI = 1.07, 2.64) marginally had higher odds of diarrhoea cases compared to children aged 0–5 months. Mothers who had 1–3 antenatal visits (OR = 1.48, 95% CI = 0.94–2.33) were less likely to have reported ARI symptoms compared to those who had zero visits. Surprisingly, no association was found between breastfeeding practices and anaemia. However, further analysis revealed

Table 18.2 Association between breastfeeding and childhood morbidity with covariates

	Diarrhoea		ARI		Anaemia		Fever	
Variables	M1	M2	M1	M2	M1	M2	M1	M2
BF practices								
Exclusive BF	1	1	1	1	1	1	1	1
Not BF	2.88* (1.63–5.07)	2.96* (1.56–5.62)	3.56* (2.05–6.17)	2.47* (1.23–4.98)	1.41 (0.89–2.22)	1.57 (0.98–2.50)	4.37*[0.00] (2.34–8.14)	4.96* (2.61–9.40)
Predominant BF	3.19* (1.84–5.52)	2.80* (1.53–5.13)	2.76* (1.57–4.82)	2.17* (1.17–4.01)	1.51 (0.97–2.35)	1.40 (0.89–2.20)	2.77*[0.02] (1.45–5.31)	2.58* (1.33–5.01)
Partial BF	3.15* (1.98–5.00)	2.96* (1.80–4.86)	3.20* (2.01–5.09)	2.21* (1.22–4.01)	1.26 (0.91–1.76)	1.26 (0.90–1.77)	4.46*[0.00] (2.61–7.63)	4.41* (2.55–7.59)
Child age								
0–5				1				
6–11				1.68* (1.07–2.64)				
12–23				1.48 (0.94–2.33)				
Sex of child								
Male								1
Female								0.66* (0.52–0.86)
Size of child								
Small						1		
Medium						0.74 (0.52–1.05)		
Big						0.65* (0.47–0.91)		
Wealth quintile								
Lowest						1		
Second						1.31 (0.93–1.83)		
Middle						1.65* (1.17–2.33)		
Fourth						0.86 (0.55–1.25)		

(continued)

Table 18.2 (continued)

	Diarrhoea		ARI		Anaemia		Fever	
Variables	M1	M2	M1	M2	M1	M2	M1	M2
Highest						0.86 (0.56–1.34)		
Occupation								
Not working								1
Professional worker								0.56 (0.18–1.72)
Sales/services								1.51* (1.02–2.23)
Agricultural worker								1.90* (1.29–2.79)
Manual worker								1.47 (0.91–2.39)
Birth interval								
Short		1						
Optimum		1.42* (1.04–1.93)						
Large		0.90 (0.62–1.32)						
Place of delivery								
Home						1		
Government						0.63* (0.48–0.84)		
Private						0.47* (0.26–0.84)		
Antenatal visits								
0				1				
1–3				0.46* (0.23–0.92)				
4+				0.60 (0.34–1.08)				
Type of floor								
Improved		1						

(continued)

Table 18.2 (continued)

	Diarrhoea		ARI		Anaemia		Fever	
Variables	M1	M2	M1	M2	M1	M2	M1	M2
Unimproved		0.62* (0.42–0.89)						
Cooking fuel								
Gas/electricity		1						1
Coal/charcoal		3.08* (1.61–5.91)						1.23 (0.74–2.03)
Wood		3.34* (1.80–620)						1.74* (1.07–2.83)
Straw/crop		3.69* (1.32–12.06)						1.27 (0.41–3.99)

BF Breastfeeding
*Statistically significant at $p < 0.05$

that size at birth, wealth quintile of mother, and place of delivery could be important distant confounders.

The odds of experiencing fever were higher among children not, predominantly, and partially breastfeeding compared to those who were exclusively breastfed (Table 18.2). In controlling for the influence of other potential variables, sex of a child, occupation of mother, and type of cooking fuel were significantly associated with fever. Female children (OR = 0.66, 95% CI = 0.52–0.86) were less likely to have fever compared to male children. Mothers who were on the sales or services (OR = 1.51, 95% CI = 1.02–2.23) and agricultural sectors (OR = 1.90, 95% CI = 1.29–2.79) had higher odds of reporting childhood fever compared to not working mothers. Also, children whose mothers used wood (OR = 1.74, 95% CI = 1.07–2.83) as cooking fuel were more likely to have fever compared to those whose mothers used gas or electricity for cooking.

18.4 Discussion

The chapter examined spatial variations of breastfeeding practices and childhood morbidity in the country. This was done using various clusters in which prevalence data on the study phenomena were collected during the GDHS 2014. Geostatistical procedures specifically consisting of spatial autocorrelation analysis (Global Moran's *I*), cluster analysis (Local Moran's *I*), and hot spot analysis (Getis-Ord Gi*) were applied. The latter was then used to generate composite maps to ascertain hot spots of breastfeeding practices (no breastfeeding, exclusive, predominant, and partial) and child morbidity (diarrhoea, ARI, anaemia, and fever) among the districts in the country.

The study found positive spatial autocorrelation for breastfeeding practices in the country. It further found a significant clustered prevalence of not breastfeeding largely among districts in Greater Accra and Western Region. Thirty-four districts were found to be hot spots where children were not breastfeeding. Most of these hot spot districts were located in Greater Accra and Central with Accra Metro having the highest record. Occupational factors may largely be contributing to most mothers not breastfeeding in the metropolis, or these children probably were weaned off breastfeeding early.

Generally, breastfeeding in urban areas is low compared to rural areas. It is plausible that most mothers do not frequently breastfeed their children due to their busy formal schedules characteristic of people in places like Accra, the capital city. Besides, most mothers in these urban settings are financially sound to afford baby formulae to feed their babies. And this practice certainly translates to less or no breastfeeding. Again, entrusting babies, aged at least 3 months, into caregivers' homes or crèches may account for mothers not breastfeeding in urban areas like Accra. These and other distal factors, not mentioned, might have contributed to the clustering of high prevalence values in Accra Metropolis, making it a hot spot for not breastfeeding.

Similarly, significant clustered patterns of exclusive breastfeeding were found in districts within Upper West, Upper East, and Northern regions. These were positive and spatially autocorrelated. Specifically, 31 districts, located in Upper West, Upper East, and Northern, were identified as hot spots for exclusive breastfeeding. The highest-rated hot spot districts for the practice of exclusive breastfeeding were Daffiama-Bussie-Issa, Wa Municipality, Wa West, and Bolgatanga. Most areas in these districts are rural. From the literature, mothers in rural areas tend to frequently practice exclusive breastfeeding despite presumed myths and beliefs about breastfeeding. In a study by Ayawine and Ae-Ngibise (2015), it was documented that cultural practices do not, at all times, deter mothers from practicing exclusive breastfeeding.

Another factor that probably determines the knowledge of mothers on the benefits of exclusive breastfeeding is education. In a study conducted by Boakye-Yiadom et al. (2016), high knowledge of exclusive breastfeeding among rural mothers was found. They also found exclusive breastfeeding a common practice among them. In relation to how the GDHS 2014 data were collected, exclusive breastfeeding in these areas is expectantly high since most mothers might have breastfed their children within the specified (24 h recall) period preceding the survey. The aforementioned reasons, therefore, might have led to a high prevalence of exclusive breastfeeding in identified hot spot districts, especially in the Upper West Region.

In addition, there was a positive spatial autocorrelation for the practice of predominant breastfeeding in the country with much of the clustering of prevalence occurring in the northern sector. Thirty-three districts were identified as hot spots. These districts were located in the north-eastern quadrant of the country, concentrating largely at Upper East and partly Northern. However, Gushiegu District in the Northern Region had the highest prevalence of predominant breastfeeding. The high prevalence of predominant breastfeeding in these areas indicates that mothers feed their children with breast milk and additionally add other liquid foods. As documented in related literature, even though breastfeeding is high in these parts of the country, mothers tend to introduce liquids and semi-solid foods early to children (less than 6 months) (Abang, 2013). The hot spot districts identified show that although mothers highly practice breastfeeding, they nonetheless fed their children frequently with other liquids and semi-solid foods on daily basis.

Also, there was positive spatial autocorrelation for the prevalence of partial breastfeeding. The clustering occurred mostly in the north-eastern part of the country. Further analysis showed that 17 districts, mostly in Upper East, were found to be hot spots for the practice of partial breastfeeding. Bawku West recorded the highest rate of partial breastfeeding. With partial breastfeeding, children breastfeed and also eat other solid foods. Hence, deductions could be made that mothers in this district commonly gave their children solid foods aside from breast milk. Probably, mothers who practiced partial breastfeeding in this district generally had children aged 6–23 months. These older children may be commonly consumed solid foods and at the same time might be breastfed on demand.

Similarly, the study found positive autocorrelation of childhood morbidity prevalence in the country. Prevalence of diarrhoea, ARI, and anaemia significantly clustered except for fever had prevalence patterns not significantly different than random. Seventeen districts showed a highly clustered prevalence of diarrhoea. Most of the hot spot districts for the prevalence of diarrhoea were concentrated in Upper West, Upper East, and Northern regions. A few were located in Brong Ahafo. Upper East had the highest proportion of diarrhoea hot spot districts. However, Savelugu-Nanton District in Northern Region was the hottest spot for the occurrence of diarrhoea.

In the Multiple Indicator Cluster Survey (GSS, 2011), Northern Region recorded the highest prevalence of childhood diarrhoea. Records of a high prevalence of diarrhoea in this part of the country could be attributed to environmental factors such as insufficient access to potable water and poor sanitation. These factors expose children to morbidities, and diarrhoea is the commonest. A study conducted by Cheng et al. (2013) documented that 50% of the population in the Northern Region has access to improved drinking water. And in Savelugu-Nanton, less than 50% of its inhabitants had access to improved drinking water. Again, open defecation is widespread among districts in the region despite the implementation of interventions such as Community-Led Total Sanitation (UNICEF, 2015). Also, another contributory factor may be the high consumption of foods containing diarrhoea-causing pathogens by children in the region, especially in Savelugu-Nanton.

Additionally, hot spots for ARI were commonly clustered in Upper East and Greater Accra. Also, some districts in Eastern, Central, and Brong Ahafo were identified as hot spots for episodes of ARI. The top-rated hot spot for childhood ARI was Accra Metro. In densely populated urban areas like Accra, overcrowding in slums can cause ARI among children. Aside from that, mothers in these urban-poor locations mostly resort to the usage of charcoal or fuelwood that emit agents of ARI. Likewise, children in urban areas are sometimes exposed to pollutants such as carbon monoxide, nitrogen oxide, and sulphur dioxide emitted by cars stacked in traffic. As mothers move with their children, they inhale these pollutants over time and this may result in ARI.

Hot spot districts identified for the prevalence of anaemia were located along the northeastern corridor of the country. These districts were situated in Upper East and Northern regions. However, highly significant hot spot districts for anaemia were found in Northern with Zabzugu having the highest prevalence of anaemia. This finding is similar to that of Ewusie et al. (2014) who revealed that the Upper East Region had the highest prevalence rate of anaemia.

During the GDHS 2014, blood samples were taken from children to test for anaemia and a number of children who were anaemic had low haemoglobin levels of less than 11 grams per decilitre (g/dl) (GSS, GHS, ICF Macro, 2015). This is caused by the kinds of foods children consume that predispose them to reduced red blood cells and consequently decreased levels of haemoglobin. This, therefore, suggests that most children in Zabzugu may be consuming poor diets. Thus, diets that do not contain essential quantities of iron and micronutrients are required to boost haemoglobin levels. Aside from the aforementioned reasons, there are food insecurity issues in the region and this may compound dietary deficiencies of children, hence, resulting in high malnutrition and wasting among children (Glover-Amengor et al., 2016).

There were also districts identified as hot spots of fever in the Upper West, Upper East, and Northern regions. Among these regions, districts in Upper West were commonly hot spots for the occurrence of childhood fever. Lawra and Jirapa districts in Upper West, including East Mamprusi district in Northern, recorded the highest prevalence of fever in the country. The high rate of fever in these locations can be a result of the high prevalence of malaria, since fever is a symptom of malaria that is common among children in these areas. Other childhood infections caused by viruses and bacteria among children could also contribute to a high prevalence of fever in these districts (D'Acremont et al., 2014).

18.5 Conclusions

This study examined hot spots of breastfeeding practices and childhood morbidity in Ghana. Geostatistical tools including spatial autocorrelation, cluster analysis, and hot spot analysis were applied to assess the requisite data. Hot spot districts identified for breastfeeding practices were Accra Metro (not breastfeeding), Daffiama-Bussie-Issa, Wa Municipal, Wa West, and Bolgatanga (exclusive breastfeeding), Gushiegu (predominant breastfeeding), and Bawku West (partial breastfeeding). Districts noted as hot spots for childhood morbidity were Savelugu-Nanton (diarrhoea), Accra Metro (ARI), Zabzugu (anaemia), and Lawra, Jirapa, East Mamprusi (fever). Districts that are hot spot districts for no breastfeeding are in cities along the coast, and those for exclusive breastfeeding are common in the northern part of the country. Also, hot spot districts for predominant breastfeeding and partial breastfeeding are mainly in the northeastern corner of the country. Childhood morbidity, diarrhoea, and fever hot spots are in northwestern, northeastern, and middle portions of the country. For ARI, hot spots are in the northeastern, middle, and along the coast. Childhood anaemia cases are common in the northeastern corner of the country. In addition, there is significant association between breastfeeding practices and childhood morbidity in the country. Potential risk factors linked to breastfeeding practices and diarrhoea are birth interval, type of floor material, and cooking fuel. Also, age of child and antenatal visits are influence associations between breastfeeding and ARI. For breastfeeding and anaemia, size of child, wealth quintile, and place of delivery are potential risk factors. The sex of a child, occupation of mother, and cooing fuel can have effects on breastfeeding practices and fever episodes.

18.6 Policy Implications

This study highlights the risk factors of childhood morbidity (diarrhoea, acute respiratory infection, anaemia, and fever) among children less than 2 years. It thus broadens the knowledge base of ascribed possible causes of childhood morbidity among young children in Ghana. Moreover, the study has simplified the identification of high prevalent areas of breastfeeding practices and childhood morbidity that could aid health planners to effective implement interventions to yield better outcomes such as reducing health care cost in the Ghana and Africa as a whole. For instance, in Ghana, a study on new born health estimated that related interventions could reduce economic value of childhood morbidity to GH¢ 30.3 million (Asuming et al., 2020).

18.7 Strengths and Limitations of the Study

The main strength of this study is that it used a large nationally representative data set to analyse breastfeeding practices and childhood morbidity in the country. This was done using various variables at the individual, community, health, and environmental levels. Another strength is that it applied geostatistical approaches to identify hot spots of breastfeeding practices and childhood morbidity across the country. Notwithstanding all these strengths, the study has a number of limitations.

Limitations embedded in this analysis include the inability of this study to assign any causality to its findings. Also, there is likely to be a recall bias since mothers reported cases (diarrhoea, ARI, anaemia, and fever) within the last 2 weeks preceding the survey. The prevalence of diarrhoea varies seasonally and data for this study were collected between September and December; hence, interpretation of results should be linked to this time period. Another limitation is the issue of over reporting (less occurrence) or under reporting (more episodes) childhood ARI symptoms by mothers. Also, no laboratory test was used to examine ARI among children. Rather, ARI was measured by asking mothers, a proxy question on whether a child coughed within the last 2 weeks preceding survey.

Anaemia was diagnosed using haemoglobin levels (protein in red blood that carries iron and oxygen to cells) of children instead of serum ferritin levels, which can distinguish iron deficiency anaemia and anaemia of chronic disease (anaemia of inflammatory response). This could have led to overestimation of the prevalence of anaemia among children. The cross-sectional nature of the data for fever used for analysis is susceptible to bias due to low reporting or misclassifications due to recall bias. The prevalence of fever was measured only within the last 2 weeks preceding the survey. Therefore, mothers' evidence of fever was subjectively based on whether a child had high temperature. With the spatial analysis of breastfeeding practices and childhood morbidity in the country, only a single-year data was used to identify hot spots. A multiple year data could have increased the analytical power. The hot spots identified are not specific target localities within districts. They are approximations.

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Chapter 19
Test-Tube Transnationalism: Fertility Migrants and Reproductive Refugees and the Provision of Care Across Southern Africa

Rebecca L. Upton

19.1 Introduction

> *Two hundred pula for my cousin to take me to the border and that doesn't include the eggs, the sperm, the equipment, those are thousands…no, that's the fee to get across but you never know if you'll be allowed to get to the clinic because people know you are desperate, they know you are invisible, they know you are vulnerable…those men in the middle…they used to be the migrants looking for success, now it is me.* ~ Esther Moseki

Historically, transnational migration throughout southern Africa involved men who moved in ways that maximized economic strategies and both conformed to and resisted colonial control over productive bodies. The role of social networks and subsequent analyses became central to the disciplinary study of transnationalism although largely overlooked the role of reproduction or women until the role of remittances and the movement of men and monies were highlighted. Increasingly however, women as agents and migrants themselves entered the discourse and today, coupled with cultural imperatives on the value of fertility and national narratives on being AIDS free has prompted a growing class of new nomads in southern Africa – fertility migrants. This chapter builds on existing literature that examines motivations, patterns of behavior and risk factors associated with transnational migration while situating those risks and behaviors in a context of shifting reproductive options and outcomes. I highlight several case studies of women whose lives have been shaped by the landscape of infertility in southern Africa. I follow them across borders, both national and familial, as they navigate barriers and success stories of assisted reproduction.

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Fig. 19.1 Map of southern Africa. (From: Hepburn, 2022)

The majority of my research is focused throughout southern Africa and with a primary base in Botswana. Botswana is a land-locked country with a population of about two million, situated to the north of South Africa, and east of Namibia (see Fig. 19.1) destinations for many of the fertility migrants with whom I work. Botswana is often considered a success story given the relatively stable political environment, smooth transition to independence, development, wealth from diamonds, cattle, and tourism, all of which have helped bolster the economy in the past several decades. Even with the impact of some of the highest incidence and prevalence rates of HIV/AIDS of those same decades, Botswana remains economically stable, with development tied in many ways to HIV donor monies as well. The majority of the population lives along the eastern corridor of the country, along paved roadways between the capital Gaborone to the south, to Francistown and

Maun in the east and northwest, respectively. The Kalahari desert occupies the great majority of the central part of the country with the Okavango delta, a tremendous draw for tourists from around the world. Pre-COVID-19, the borders between many of the southern African states were porous, transit was straightforward and exchange, and import/export and movement was relatively uncontested (Upton, 2022).

19.2 Literature

19.2.1 Gender, Migrants and Refugees

The ethnographic data in this chapter reflect the persistence of movement of people across African borders and the interesting ways in which they see themselves as both ‘migrant’ and ‘refugee’. Women with whom I’ve worked refer to themselves as *both* and yet are fully aware of the UN definitions of migrants as those who have agency, who choose to move in search of social, educational, or financial improvements, and refugees as those who are more forcibly displaced and fear persecution and dire outcomes should they return (UN Convention on Refugees, 1951). Surely women who are engaged in transnational fertility migration are not akin to those fleeing conflict, but for many, as I outline further below, the idea of returning to a home village, a country or their community in the same ‘state’ as they left, without aid in their search for reproductive success, the cultural persecution, the stigma, is debilitating. Migrant and refugee status also suggest dynamic status – that movement toward a particular goal is constant and not static – seems appropriate and is a theme carried in the narratives of women who are traversing southern African terrain.

The terrain that women cross in southern Africa is both literal and figurative. It is also expansive. As Speier writes in her work on IVF tourism, ‘[t]he multitude of reproductive travel routes is “varied” [worldwide]…and it is impossible to know how many people are traveling internationally for this type of care (Nygren et al., 2010)’ (Speier 2016:5). Nevertheless, as Speier (2016), Inhorn (1994), Inhorn and Van Balen (2002) all highlight using ethnographic narrative data, fertility migration is deeply gendered and women are largely those who are subjected to the physical, psychological, and social pressure to have a child. As Speier suggests, it is the ‘labeling of infertility as a woman’s problem [that] drives the gendered nature of virtual biosocial communities…it is through the Internet that women learn about global routes to parenthood’ (p. 47). While Speier’s work focuses on reproductive tourism in Europe and the global North, it is relevant here given the persistent characterization of infertility as a female ‘problem’ and the rise in online communities of care and information that I saw as well in social media connections and fertility communications across southern Africa. Yet importantly, communities of migrants are also marked by discord and disconnect and are not homogenous even with similar goals and desires. As Whitehouse (2012) describes, migrants seek fortunes of all sorts as ‘strangers in the interstices of the global economy’ (p. 220) and yet the relationships between them can be fraught with tensions, unease, exclusion and disempowerment – certainly this is the case for many involved in the transnational fertility movements of southern Africa.

19.2.2 Citizenship and Culture

Ong’s long thinking and development of the notion of ‘flexible citizenship’ is particularly useful here, where individuals and their national identities are shaped by and through their navigation of capital exchange and the commodification of bodies. Most recently, she states that ‘…[a] monopoly of digital informational technologies…enables [the state] to more thoroughly construct citizenship based on collective surveillance rather than individual rights’ (2022:599). Here, the role of digital, technological and health surveillance strategies that reproductive refugee/migrants use to fulfill their fertility goals precisely reflect Ong’s observation. That is, that collective, cultural imperatives on the value of childbearing necessitate technological tools, social media, and more underground strategies to connect ‘buyers’ and ‘sellers’ of reproductive goods. These tools and strategies are the basis for understanding new social networks in southern Africa and their facilitation of a digital diaspora of reproductive care. Increasingly, studies of development and health are grounded in understanding ehealth or mhealth (electronic health or mobile health, respectively) as the ways in which communities in need of care will be best served and connected (Birnbaum et al., 2015) whether focused on fertility or not.

While reproductive and sexual health have arguably always been entangled with studies of labor and even forced relocation, the literature on migration in southern Africa typically rests on accounts of individuals engaged in transnational movement for the purposes of employment. Usually, migrants are understood to be moving away from rural sending communities to wealthier, urban, and more populous sites. Studies of formal migrant labor systems and social networks, such as those that grew out of the Manchester School foci, necessarily examined those most closely associated with moving populations (the male migrants themselves). Others have most usefully built upon those studies to more closely examine the construction of the migrant and African laborer as both resilient and fundamentally flawed or diseased (cf. Packard 1993). More recently, in the past several decades, as scholars turned their attention to the impact of HIV/AIDS on the continent and throughout southern Africa specifically, studies moved away from simply seeing migrants as ‘crucial communicators of culture’ (Mojola 2014: 65), or those tasked with sending remittances and navigating conflict zones (Nordstrom 1999), to research on patterns of risky sexual behaviors (Caldwell et al., 1997) and masculinity (Chirwa 1997, Lurie et al., 2003), and largely focused on women as vectors for the spread of the virus (via prostitution or multiple concurrent sexual partnerships) (cf. Coffee et al., 2007).

In reality, as Lurie and Akileswaran (2010) point out, ‘women have been moving throughout history and not in insignificant numbers. South African census figures from the early 20th century verify that 19 percent of the population in urban centers (which housed the male migrant workforce) was women’ (p. 179). While the authors are focused on the impact and intersect of HIV/AIDS with female migration, they note that ‘it is essential to view the migration of women as not just an economic process but a socially transformative one as well…[t]he social context of female migration can help us to exploit the collective agency exhibited by a network of women migrants in order to cultivate mutually reinforcing, risk-minimizing behaviors’ (p. 193) and, I would argue, can better aid understanding of even more contemporary concerns such as navigating the rather deserted fertility landscape of southern Africa.

19.2.3 Unmet Need and Development

This ethnographic research is grounded in the assumption that infertility is indeed a global health concern and while not always statistically significant, certainly socially so. While estimates suggest that approximately 10% of couples worldwide are infertile, the reasons and consequences of involuntary childlessness vary across contexts (Ombelet and Onofre, 2019). Additionally, one of the challenges in implementing health promotion strategies that consider infertility as a problem in Africa is ‘the widespread belief that infertility is not a pressing problem in poor developing countries’ or amongst African populations that are already cast as overpopulous. (Ombelet and Onofre, 2019:70). Yet, as Dyer and Patel (2012) suggest, infertility may in fact cause impoverishment and structural inequalities to persist. Increasing access to assisted reproductive technologies (ART) to those across the continent (and certainly in what has been labeled the southern African ‘infertility belt’ cf. Inhorn 2003) will continue to create development opportunities and enhance overall population health and wealth. Figure 19.2 illustrates the dearth of registered IVF fertility clinics throughout the continent. Clearly, those sites with resources and access to address unmet fertility needs are not only essential in the lives of those struggling with infertility but simultaneously (and unintentionally) reinforce structures of health inequity and under-development.

19.3 Context and Methods

In 2011 Esther Moseki, an upper middle class MoTswana woman living in a wealthy suburb of Gaborone, the capital of Botswana described for me the process of modern-day fertility migrancy. As she stated, this is not a cheap or frivolous undertaking, not something that everyone can do, but certainly something that everyone might do given cultural imperatives on the value of children in Botswana. Child fosterage, multiple concurrent partnerships and as I have argued elsewhere, the role

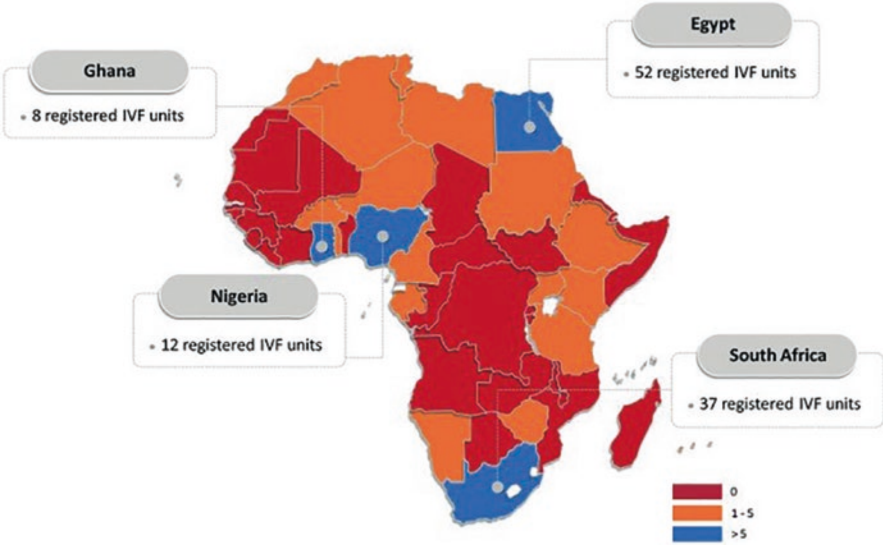

Fig. 19.2 Distribution of registered IVF clinics. (From: Ombelet & Onofre, 2019)

of 'sleeping fetuses' to explain lengthy pregnancies when partners were located elsewhere and viable partner more immediate, have all been part and parcel of the reproductive rhetoric in this part of southern Africa. I would come to rely heavily on Esther as a key respondent in my work and hers is one of the case studies that I include in this chapter.

A year after I met Esther, in 2012, the first fertility clinic in Namibia opened. Middle class Tswana migrants from Botswana (where IVF and ART are nonexistent) began to constitute a significant proportion of the clientele served in the Namibian clinic. Tswana and other migrants from Zimbabwe and Mozambique are also now traveling to South Africa as 'reproductive refugees' and seek care at clinics in Sandton, Cape Town and Umhlanga. It became clear that a fertility exodus was underway as more and more women that I met through snowball sampling methods were traveling hundreds of kilometers in search of these sites and reproductive success.

So, a few years after I first met Esther, beginning in 2015, and building on prior research and longstanding relationships with key interlocutors, I followed, migrated with, repeatedly interviewed and lived with over 30 women who were grappling with infertility, and subfecundity. These were women across the socio-economic spectrum, some highly educated with university degrees and others who went through primary or maybe secondary school. All were seeking assisted reproductive technologies across southern Africa. Over the course of the past 6 years, I've traveled with these women, sharing their trials and joys at various reproductive outcomes, I've been a participant observer in numerous births and tried to support others through failed attempts at IVF and other assisted reproductive technology (ART) interventions.

I've become well-versed in Twitter-language and short-hand messages and hashtags that help facilitate the exchange of reproductive 'goods' – learning about eggs and sperm as kinds of 'remittances' for those traversing national boundaries in search of 'family'. My ethnographic findings describe how the new female frontierswomen, the fertility migrants, a privileged but paradoxically stigmatized class, are synthesizing messages about safe sex and tropes of 'protecting oneself' with long held beliefs about the normativity of migration in crafting Tswana identity. I gathered and have analyzed over 50 open-ended interviews with the 30 women. These data were coded using MAXQDA software and checked twice for reliability with native Tswana-speakers and my long-time research collaborative assistants. The codes and themes that emerge provide the springboard for my analysis here. The three case studies that I include are illustrative not just of individual lived experiences, but reflect aspects of the varied journeys of all 30 women and the names used here are pseudonyms. Throughout the first 4 years of research, I had traveled multiple times (sometimes more than two round trips across the South African border post a day) across national borders, and for the last 2 years during the height and waves of the COVID-19 pandemic, I've kept in close contact with my respondents via the very means that they are securing reproductive 'goods', on mobile platforms such as Twitter, WhatsApp, SMS and Zoom.

19.4 Case Studies

19.4.1 Fertility Migrants: Women and Technology

One of my early encounters with fertility migrancy occurred when I accompanied my friend Dineo across the Tlokweng border from Botswana to South Africa in early 2016. We were hitching across the border to meet a woman that Dineo had connected with on Twitter and to barter over some donor sperm and eggs. Dineo and her boyfriend had been trying to have children for some time and had been told both by an ob/gyn and by a traditional healer in Dineo's home village near the rural community of Maun, that their 'blood did not agree' and thus their problems 'falling pregnant'. As I note elsewhere, while there are medical services in Botswana, and care that rivals many contexts in the West, assisted reproductive technologies and services are non-existent. Whereas IVF, ICSI, GIFT, IUI, egg donation, mail order sperm and online frozen embryo (or 'snowflake babies' as they are known in the West) are ubiquitous as options in contemporary USA and Western reproductive life (for those who can afford it of course), the same is not true for women such as Dineo (Upton, 2020). Caught between development, modernity *and* persistent cultural norms about reproduction, Dineo was using hashtags such as #madiamasweu#foryou, #madimae and #Polokwane#pulaonly#donoreggs, visible markers of an invisible struggle and located in virtual spaces, in order to fulfill these oft-competing imperatives.

19.4.2 Twitter, Transnationalism and Assisted Reproductive Technologies

The relative dearth of assisted reproductive technologies (ARTs) or registered clinics as noted above, in this southern African region, has greatly influenced migration in contemporary Tswana reproductive life. But while migration has long been a part of life in southern Africa, Twitter and the ability to communicate across multiple boundaries in the search for fertility options has revolutionized the fertility landscape in this region – synthesizing novel, contemporary practices with culturally logical movements and migration. Thus, while in the West, Twitter and other social media provide essential, virtual support communities for the infertile, such communities provide palpable resources and are pathways to fertility products in Africa. Connections across cultural, geographic and online divides are easily navigable online where 'infertility frustrations, success stories, advice and assistance are facilitated…' and made visible in the West, where '[b]oundaries between public and private, individual and communal discourse are revealed through hashtags and content analyses of tweets related to infertility' (Upton, 2020).

In this research, given the sharp rise in Twitter usage throughout southern Africa (the region accounts for over 75% of all tweets across the continent), I noted just prior to the COVID-19 pandemic that 'tracking the Twitter transactions with respect to ARTs is illuminating and represents a new context and lens through which both migration and fertility intersect and re-envision the meaning of gender and reproduction' (Upton, 2020). I observed that Dineo and others like her were increasingly reliant on Twitter for informal connections and information about the range of ARTs and access to *actual* resources, forcing a new kind of transnational migration in search of full personhood, parenthood, citizenship and gendered identity. Clearly '@EggDonor and @Fertile_med' are as resonant along the transnational borders in southern Africa but here the tweets are in SeTswana, SeSotho, Afrikaans, and other languages and indicate larger structural inequities in access, gendered obligations and the agency that social media can provide to those whose reproductive abilities render them invisible.

19.4.3 Dineo's Story: Fertility Logics and New Digital Diasporas

One day Dineo shared the following:

> When I was a small child and I stayed with my grandmother up north at the cattlepost, I remember her telling me about her sister, my great auntie…the story was that the woman couldn't have any children, that nobody wanted to go near her because they thought she was cursed, that she broke taboos, that she was a jealous person and that was why she couldn't seem to have any children with her husband. Nobody would even let their children near her and even my mother was told that she should be careful, that she should watch out for her

> auntie who might bewitch her and make it so she couldn't have any more children…[laughs] but my mother did and was kind and I have two brothers and a sister just fine so she escaped the warning. But then her aunt fell pregnant and her uncle was away in South Africa working so the baby stayed inside until he returned. My mother and grandmother always talk about how that child was a miracle, a 'sleeping fetus,' born after 17 months of pregnancy and a child who was so wanted that it waited for its father to return before it would be born. [Laughs] when I tell people this story, if they are not from Botswana, and even those who are younger these days, they always conclude that my great-auntie had another partner who helped her get pregnant. Sometimes they're scandalized, other times they're like you [laughs] and talk about the rise of multiple concurrent partnerships in Botswana and the rise of HIV/AIDS, but the thing that is important is what my mother and grandmother always say…nobody in the village was upset. Even my great-uncle, he was fine, he was happy, he celebrated that he had this child, it solved their problems and the suspicions and stigma of infertility, all that went away. It was logical, a lovely solution for everyone and, it was low-tech.

The key to Dineo's story, and it is one that I have encountered in various ways over the course of two decades of research on infertility and HIV/AIDS in Botswana, is that the explanation of the 'sleeping fetus' is a culturally logical (and acceptable) one. Indeed, as Dineo herself points out, it is low-tech, and while such a strategy remains a salient 'solution', it is also an intriguing precursor to contemporary strategies and online Twitter communities, employed by women who are seeking positive fertility outcomes in a context with limited (to no) ART resources. As a close friend of Dineo's once shared, 'you can get almost anything online, not shopping online like you do with Amazon but you put it out there, you let people know what you are looking for, sperm donation, donor eggs or maybe they tell you what they have to give you, embryos or eggs or even frozen sperm leftover, and you find them, you connect...but you have to do it across the border'(cf. Upton, 2020). Given that cultural mores that to be a reproductive, productive or 'full' person in Botswana means that you are a fertile person (Schapera, 1953, Suggs, 2001), then the emergence of a new digitally driven diaspora and transnational migration by women in this most recent era is exciting and necessary. As bodies are scrutinized for their reproductivity in traditional contexts, the surveillance of bodies and reproductive products create an interesting hierarchy, raising issues of health equity and accessibility across geographic locations.

The useful albeit dated concept of 'imagined communities' (Anderson, 1983), which has been so very salient in discussions of transnational migration and the social construction of the state through media and material culture, is challenged a bit by cases such as the one of Dineo's great-aunt. As social media takes center stage in the lives and journeys of those seeking ARTs, perhaps more accurate today are Appadurai's techno and mediascapes, where *what* is being imagined and *how* it is being imagined has become even more central than simply where communities are located. It is not insignificant too that bodily products are always subject to potential witchcraft, a central and recurrent theme in my data. Indeed, in 2010, the then nascent University of Botswana medical school encountered tremendous problems when trying to teach enrolled students, and future physicians, Gross Anatomy as few Tswana feel comfortable with organ or cadaver donation and thus the med school had no ‘human’ resources to learn from and teach with. And Dineo’s great-aunt is far more apt to find success with culturally logical strategies such as ‘sleeping fetuses’ too, especially given the legal status question of fertility technologies in the country. The Public Health Act, re-envisioned as I was starting this work and subject to a good deal of public debate these days, addresses the use of gametes and tissues of the living for use by another and most, if not all, are prohibited. And in spring of 2019, Dineo told me of a new (and still only) fertility clinic in the nation that has opened in Gaborone. Run by Dr. Molelekwa, the Gaborone Fertility Clinic is the first in country to offer a range of IVF and related services. But only for the very wealthy.

Nevertheless, the new movement of fertility migration and the creation of a digital diaspora of fertility products in order to fulfill cultural imperatives that are grounded in gendered identity are beginning to have striking outcomes in this region. New transnational forms of kinship may arise and may or may not be recognized as I describe in the third case study below, and there is some argument here too about how in an increasingly global community can cast fertility migration as either a deleterious facet to outsourcing reproduction **or** as a means through which those without ARTs can strategize via technology and exercise their own agency drawing upon culturally logical and long-standing patterns of migration.

19.4.4 Thaloganyo Phiri: A Barren Landscape

Even prior to my travels with Dineo, with the advent of new reproductive care clinics in Namibia in 2012, clinics that specialized in and offer fertility solutions through a range of technologies, Thaloganyo Phiri was adamant that she was going to make the trek from Maun to Windhoek in order to finally get some help falling pregnant. I’d known Thalo for several years at that point and we’d spoken often about her struggles with infertility. In fact, she was one of the first women I know of to travel internationally in search of assisted reproductive technologies such as IVF. Thalo had had a long-term boyfriend, Prince, they’d met early as children and lived in neighboring villages. They’d dated and stayed together through much of their school years and it wasn’t until Prince left for the University of Botswana down in Gaborone that their relationship faltered. As Thalo described,

> Everything was new and exciting and difficult, his classes were difficult and I think he spent a lot of time trying to prove who he was, that he wasn’t going to fail at University. There were a lot of parties and I was not there…we started to drift apart, to talk to other people. When he was home, back up north we had talked a lot about having a child but I just couldn’t seem to fall pregnant. I was the one who ended up feeling like a failure.

Thalo had not gone to the national university in Gaborone, rather she had stayed close to her family and was training to work in one of the more prestigious and environmentally conscious tourist camps in the Okavango delta, the sources of fairly high paid employment for many in the region and touted as the key to Botswana's stability and economic development.

> I stayed in Shorobe, my home village, but I was doing training courses to begin working in the delta at one of the camps…those are good jobs, they pay well and I was always a child who loved the environment, loved showing people, BaTswana, foreigners, it doesn't matter…I love teaching them about our land and the animals and how to protect them. It was a great path that God had laid out for each of us but we just didn't end up following it.

Over several conversations I eventually learned that despite believing that there was a divine plan for her and her boyfriend, that they were 'meant to be together', Thalo allowed that things became complicated as Prince made new friends and new girlfriends and there were jealousies on all sides. As she put it,

> I just never could fall pregnant. I just couldn't, even without Prince here, nothing I did worked, there was never a child to welcome him back. I go to church but I am telling you what my auntie said, she told me that one of his girlfriends at school, she has put a spell on him and it means that he cannot see me, I am invisible to him and no child, no *madi a masweu* [literally "white blood", or sperm] will be able to find me either, I'm like a ghost.

Eventually the two parted ways, Thalo was busy working as a guide and then camp manager in a remote, high-end tourist camp that was fairly inaccessible (requiring a small plane flight and several kilometer bumpy, dusty Land Rover drive) and Prince returned to their home villages to visit only rarely and became much more focused on his coursework, eventually pursuing a Master's degree in environmental science and fisheries at the University of Tromsø in Norway. Thalo always describes their eventual parting as amicable but was, and is, equally convinced that some form of 'old school witchcraft' (akin to the themes in Dineo's stories and others) was performed on her by one of Prince's girlfriends, rendering her incapable of carrying a child.

For Thalo, the news that a clinic had opened in Windhoek, Namibia (closer in many ways to those living in northern Botswana and more accessible by vehicle than traversing the Kalahari to get to clinics in South Africa from the north, for example), she was optimistic. Thalo has a comfortable, middle-class salary working for the expat-owned bush camp is well respected, works hard and shortly after the new year in 2013, she took a ten day leave and went to Namibia. Thalo was one of the first bonafide and self-named 'fertility migrants' that I would come to know and work closely with and over the years I've witnessed her traverse some fairly emotional as well as expansive geographical terrain. After her first visit to the clinic and acceptance as a client, Thalo would return on multiple occasions, and after weeks of follicle hormone stimulating injections, for egg retrieval and hopeful next steps in the in vitro process. Unfortunately, and despite the range of options offered by the clinic, none had worked and like those struggling with infertility in the West and Global North, the costs of ART were taking their toll on Thalo. As she put it,

> I felt like everything about me was drying up…like the desert that I felt like I was crossing all of the time now, and the sand dunes that were always there when I arrived in Namibia, I felt like my body was just dry, nothing would grow there. And my bank card was running low too, there was hardly anything left in there either and I was going to have to work more weeks to be able to afford the clinic. It really did feel like I was going to dry up and blow

> away someday on my way to the clinic, that there was just nothing left to me, that I was still a ghost, flying away in the wind over those deserts.

The sheer number of times and travel (at times dangerous given the road conditions along part of the Maun to Windhoek route with multiple potholes and blown tires a given) means that there are myriad, intersecting tolls on bodies that are on the move. The cost of a break in the cold chain too, the costs of refrigeration and the precarity of coolers filled with hormone therapies, frozen embryos, sperm or eggs, traveling in a hot, desert climate, all mean that the cost of infertility is high even while navigating the newest, transnational strategies.

For Thalo too, the issue of racial identity immediately became part of her migration landscape. While Thalo was in a precarious position as a woman seeking assistance for fertility problems, she was also a black African woman in a clinic that was largely accessed by white, Namibian women. Thinking through race and nationality in addition to the insecurity of female infertility made everything harder. For example, when choosing a sperm donor, she'd had options of both white and black African donors and once she had to consider the possibility of using both an egg and sperm donor, or frozen embryos that would be implanted her uterus, Thalo remained surprised that so many of the options 'did not look like me, did not look like a baby I would have and it seemed clear that someone like me was going to be, or have children as second-class citizens.' She was in a liminal place and old assumptions about ideal bodies still filtered into discourse about future family options in a rarefied clinic. Speier (2016) in her book about those who embark on 'fertility holidays' observes that the search for reproductive assistance and success, no matter what the format (e.g. via tourism or migrancy), all serve to reinforce global systemic racialization and economic stratification that inevitably cement gender subordination as well.

Thalo is left as a kind of reproductive refugee – she is without a 'home', a family. She has challenged (whether wittingly or unwittingly) cultural norms about *who* migrates and why. Additionally, she avails herself of the newest and innovative strategies to try to fulfill those cultural imperatives. She has more financial options than many in northern Botswana certainly but remains caught in a somewhat dislocated state between fertile and infertile and never feels a sense of being 'home'. Thalo's older sister Puleng (whose name literally translates as 'born of rain' synonymous with abundance, fertility and wealth, and who has three children herself) confided in me one day summarizing Thalo's predicament,

> My sister has always been on the move, even though she stayed in our home village when Prince had gone to university, she was moving forward, looking for the next job and always wanted to better herself and help our family. But now she's on the move again, trying to find a way, what our parents call a *lekgoa*, or Western way, of helping herself, building a family. I wish she could stay put, that she felt at home and had a child. It doesn't seem that a child wants to grab onto her, it just slips out, the procedures aren't making her strong enough, her blood is weak.

In the meantime, Thalo has kept trying and has even turned toward more the more informal strategies, maximizing her fertility potential by engaging in multiple concurrent partnerships (MCPs) with others and placing herself at high risk for sexually transmitted disease, HIV/AIDS, and intimate violence, and dependency on the fertility of others. Nothing has worked.

19.4.5 Esther Moseki: A Fertile Landscape

I met Esther Moseki, a well-educated, urban Tswana woman, around the same time that Thalo was beginning her trips to Windhoek in search of fertile outcomes. Esther and I were in Gaborone and were both attending a seminar at the local university on the impact of urban planning of the city on community health outcomes. I was curious about the growth and design of the capital city in general, but Esther was there in her capacity as a manager for a telecoms company. Her employer at the time was one of the largest telecommunications companies to have a foothold throughout southern Africa, and there was growing interest in expanding their network of coverage to more rural areas, particularly as the Ministry of Health was beginning to roll out expanded access to HIV care in the form of subsidized antiretroviral therapies and Pre-Exposure Prophylaxis (PrEP) to those at high risk in those less populous areas. Esther was tasked with researching how young adults in particular were navigating the capital city, how they utilized technologies such as cell phones (particularly in a context where cell phone use by Africans was skyrocketing), and what kinds of plans and technology would need to be in place to implement nation-wide telehealth and better communications overall. In the course of getting to know one another, Esther and my conversation and friendship veered into my research and she had much to share, stating,

> You are describing my life…I've done just that, there is a woman I know well in Rustenberg and she had a cousin who was willing to help me when it was clear that I wasn't going to be able to get pregnant or carry a child. The cousin was younger and fortunately [laughs] I am good at using all the social media apps and hashtags so I knew how to connect with her and soon learned the 'language' of online reproductive assistance. It was not long before I was following threads and tags like #madilemae [money and eggs], #Tlokwengbordereggs, #pulaandprivacyformadiamasweu [money and privacy for sperm] and even ones about #mosadiyomongwengwana [surrogate motherhood] despite the fact that I was not interested in surrogacy, I was social networking and casting a wide net, I needed options.

While it was heartbreaking to listen to Esther at times, it was also clear that through her work and the role of technology, the barren landscape could be transformed – ART, like age-old forms of development strategies, offers hope – hope for improved health and wealth outcomes. She had both networks and the social, financial and technological means to utilize them and reflected, 'someone who has a lot of money, or status, we talk about those people and say, they are a 'big person', big people have a lot of power…many in my home village thought I was a big person, but then they found out I didn't have a child and I was invisible again, like a child myself.' Esther's hard work and strategizing to fulfill her desires and cultural demands for fertility highlight that the movement of women across southern African landscapes is most definitely ***not*** about abandonment of family obligations. Nor should it be read as a break with traditional mores and expectations that migration was and is masculine terrain. Rather, Esther's story reminds us that more contemporary expectations mean that female fertility migrants are agents in shaping their own reproductive outcomes and social success. They are not passive subjects upon which infertility has been visited, but as Esther reminded me,

> There are options, women have options…back in the day, when our grandmothers were seen as barren, as *moopa*, many would have feared witchcraft as the cause, as the reason they couldn't bear a child or people in the village would suspect that they had broken some taboos. So either, someone performed witchcraft on you because they were jealous of something you have or you did something wrong in your own actions. It is not that much different today, people are quick to judge and label you if they see you without a child, they are suspicious – what kind of man will want to marry you if you don't have a child? But I think today, if we have the option to go somewhere for help, they women will do that, I wasn't going to wait for someone to say that I had done something wrong.

At one point Esther recalls hearing people in her office jokingly refer to her as someone who was a bit obsessed with having a child, she recounted how,

> There was this one colleague of mine, also working in rural telecoms and traveling a lot. He knew I'd been trying to connect with someone about getting sperm and maybe even an egg donor – he even joked that he could help. But he was telling others in the office that he could tell I was going a bit mad about it, the expression '*popelo e ile thlogong*', or the womb has gone to the head, it can be used to describe infertility but historically you only heard women had had suffer mental illness described this way. The thing is that he was not wrong…I felt like I was going crazy, that all I could think about was having a child, it had gone to my head, but the label of mental illness in our community, particularly at work, that was awful…one woman, an older woman in the office said it reminded her of when her aunt would talk about someone who was cursed, was crazy and there was no solution, nothing she could do.

But for Esther, doing things, being proactive and using the tech tools at her disposal, learning the language of 'online ova shopping' (her description!) and bartering in some cases with women across the border, was something she could do. She refused the label of infertile in the same way she rejected traditional beliefs about witchcraft or the stigma of mental illness. As she told me,

> Even when I was just starting, I was looking at donor sperm [and most donor sperm that one can buy outside of a fertility clinic was handled through female traders] and connecting with other women in South Africa, in Polokwane and Ramatlabama mostly up north, I felt as if I was the one in charge, this terrible situation was upon me but I was the one who was going to be able to fix it, to find a way to have a child and there was nothing stigmatizing, or sickness-causing about that, it was very empowering. I was really very sad then and lots of unknowns, but to be honest, it was also a lot of control.

Eventually Esther became pregnant (she estimates that it took a total of 7 years, too many texts and tweets to even begin to count, fourteen 'attempts' including follicle stimulations, hormone injections, egg transfers from a donor and frozen sperm testing) with her daughter whom she named Omphile (which means 'God provided for me', it is not insignificant that Christianity has a stronghold in this post-Livingstone, Moffat region of the continent). Esther was ecstatic as were all those in her work and family communities. She traveled by combi, by bus, by multiple means of transportation throughout this uncertain and emotional journey. Interestingly, what Esther is now concerned with is the question of citizenship that Omphile raises. According to the citizenship laws of Botswana (cf. Dow 1991) and in the eyes of a majority of fertility clinics worldwide, Esther is the birth mother and Omphile, born in Botswana, is a MoTswana with citizenship rights no matter who her biological egg or sperm donors may be. But Esther wonders some about the liminality of her daughter's identity and the questions it raises. She wrote me during one of the early months of the COVID-19 lockdown to say,

> She is my daughter, I can now say I am Mma Omphile (mother of Omphile), but what do I tell her about the biology, the eggs, the sperm that were used to create her so that I could carry her? Does it matter? Sometimes it reminds me of all of those spaces in between the border posts…where you are not quite sure when you are coming and going, whether you belong, or are actually *in* one place or another. It's a no-man's land. All of this is. I wonder about who she belongs to, will someone argue with me about whether I am really her mother? And what about all the other siblings that she may have out there, here at home or over the border? I cannot even imagine where they all are.

The questions that Esther raises are not simple ones and beg a reconsideration of the meaning of borders and boundaries to begin with. Does it matter if Omphile is born of Esther or by her, a biological or social mother? Does the more public struggle for amelioration of infertility through technological means suggest that more traditional, culturally logical and acceptable strategies are more appealing and cost-effective even while increasing risks to the public's health?

19.5 Discussion

The backdrop to the transnational search for fertility for women in this study of course is the omni-present specter of HIV/AIDS. In 2002, Botswana became the first African country to offer free HIV treatment to all citizens. Yet, in this region, incidence and prevalence of the virus have remained persistently high with adult prevalence hovering around 21% of the population (BIAS V). And still, those numbers have dropped considerably over the past decade, as a result of successful and socially supported anti-retroviral (ARV) dissemination. Indeed, in the summer of 2022, laboratory director, Madisa Ontiretse Mine in the Ministry of Health publicly reported that Botswana had achieved the UN 95-95-95 campaign targets with 95.1% of people aware of their HIV status, 98% of those who were aware, on anti-retroviral (ARV) therapy and 97.9% of those on ARVs, achieving viral suppression (BAIS V, 2022). The nation narrative is one of success though the data reveal deeply gendered differences, women were far more likely to be aware of their status and seek care, than their male counterparts. Again, while much of the literature on health and migration over the past few decades has focused on male migrant bodies, concomitant risky behaviors, and assumptions about sex workers as vectors for the spread of disease, it is clear that the relationships that are built within and across HIV-prevalent regions are far more complex. The acknowledgement that resources to 'help' those struggling with HIV and those struggling to address infertility are differently allocated reinforces ideas about which disease conditions 'count' in everyday life.

Esther and others like her actively contest ideas of marginality, or traditional expectations for women to remain 'home' or in place (Upton, 2003). Today, migration is an active means through which women can avail themselves of a range of 'solutions' to potential failures as productive and reproductive persons. Migration is still an economic strategy for many, and as Esther's story demonstrates, it is both a social and a sexual-health-related one. As I've written elsewhere, when Ong (1999) called in years past for a re-thinking of *subjects* and *citizens* and suggested the concept of 'flexible citizenship' in an era of globalization, 'the practices of refugees and migrants who no longer just work in one location while their families are lodged in 'safe havens' elsewhere became necessarily complicated. The meanings, motivations and materials that moved with migration became interrogated in complex and significant ways' (Upton, 2020). More recently, as the reliance on Twitter for transnational fertility transactions, the creation of digital diasporas and of fertility migrants themselves, the idea of global 'goods' and commodities as culture 'carriers' seems salient. As Rockefeller (2011) puts it, 'cash, traffic, [and] people... all of these things 'flow'...but thinking about migration in these ways serves to reinforce (inadvertently) dichotomous ideas of places and communities that are tethered together rather than subverting that perspective and see people and their motivations as significant in and of themselves.'

In contemporary Botswana and across the border into South Africa and Namibia, the internet is a cultural product, not solely a technological one, and it exists in the intersections between those places and communities that women migrants inhabit. Here, Twitter and other social media 'carries' more than information or technology; in the case of women in Botswana who are traveling to South Africa in search of reproductive success, it facilitates the use of fertility strategies to subvert the scrutiny of their reproductive lives as they engage as productive persons in transnational contexts. Moreover, the marketization and technological innovation utilized by women – this reproductive entrepreneurship, akin to what Speier (2016) describes in Eastern Europe, means that there are invisible flows of money – cash for potential kin that reflect development, globalization and modern science and yet these relationships and transaction remain hidden. Thus, Twitter becomes a useful handmaiden to transnational citizenry but in ways that fulfill and maintain more traditional and highly gendered reproductive expectations. And migration and refugee status become more complex, nuanced and even challenged by women themselves. Long-held definitions about refugees and migrants – whether one is 'forced' to move or crosses a border by choice – the key seems to lie in whether women seeking assistance with reproduction actually experience migrancy as a choice and what happens to those who cannot find a community and like Thalo, remain in a 'childless' state.

19.6 Conclusions

In vitro fertilization (IVF) and other assisted reproductive technologies (ART) are a modern reality, ubiquitous in Western cultures and central to the discourse on fertility-driven tourism. In southern Africa, IVF and other ART remain inaccessible to many due to prohibitive cost and travel limitations. However, in a culture where fertility and fecundity signify productive status as persons, a growing number of 'fertility migrants' have emerged as a new phenomenon, although one deeply grounded in long-standing and normative patterns of migration across southern African national boundaries.

Through this ethnographic project, engaging in the lives of over thirty women across southern African borders, we begin to see a shift in the meaning of migration. Particularly as it intersects with notions of risk, health equity, and fertility, migration is clearly no longer a dichotomous and gendered pattern of behavior geared toward the amelioration of economic insecurity. Instead, through the narratives of women engaged in transnational fertility migration, it is clear that not only are women participating in greater numbers in movement across borders, but they are also doing so as agents with myriad and complex goals. As fertility migrants, they seek contemporary, innovative and sometimes invisible or inaccessible routes to reproduction beyond national or traditional boundaries. In doing so, they also draw attention to the range of reproductive health inequities that persist in this region of the African continent and even highlight how improvements in reproductive technologies, and care will improve community health overall.

As I conclude elsewhere, the 'cultural allegation that women have no tribe reflects a larger structure of gender inequality in Botswana. This gender inequality, which has rendered women socially invisible' (Upton, 2003: 321) despite their caregiving and contributions to communities that experienced large out-migration of men, and throughout the height of the HIV/AIDS pandemic, means that more recent strategies for reproductive success and women's movement as migrants themselves, remain hidden as well. With the advent of ARTs worldwide, it is not surprising that those who seek reproductive 'help' across national boundaries have increased. With improved technology and strategies to provide avenues for 'family building' worldwide, access in Botswana to redress the cultural stigma of infertility would seem an easy fit. Indeed, Botswana is a government that could, if it chose to do so, provide ART for citizens just as they do with the subsidized ARV programs throughout the country. Yet, 'to acknowledge that kind of medicalized body engenders resistance and at present it remains accessible only to those with certain resources' (ibid). In a great twist of irony, the negotiation of infertility was far more culturally accessible prior to the currently more efficacious HIV/AIDS awareness but more surprisingly, to the advent of ARTs and a construction of women as more active agents in their own fertility control.

In 2017 the World Bank published findings in its *Forever Young* report in a section entitled 'Falling Fertility in Botswana Provides Chance for Future Economic Growth'. The report reflects the nation's fertility decline, noting that between 1980 and 2015, the total fertility rate (TFR) went from 'an *astonishing'* (emphasis in the original) 6.2 children per woman to 2.7 children. While arguably a result of numerous and interrelated health conditions and the context of HIV/AIDS during that time, the main conclusions from the report include the fact that the proportion of child dependents has lessened while the number of potential labor force participants has and will increase steadily through 2050. The 'positive' outcome of a lower total fertility rate is offset but the admonishment that 'Botswana will have to act now and implement key policy reforms to allow current and future generations to harness' positive dividends from such a demographic transition (World Bank, 2017). So, it is perhaps ironic that even as a call comes for lowering fertility and raising employment and GDP, improvements in health services and accessibility to fertility care act as catalysts for even broader enhancements in African development. Conflict over fertility care too can challenge the World Bank and others to rethink fertility as a global public health issue in this region.

At the very least, as Esther, Thalo and myriad others suggest in their narratives, better access to ART and the potential for fertility treatment options would vastly improve their lives and livelihoods. To be certain, fertility clinics are big business. And bringing those technologies, clinics and facilitating more domestic (and less transnational) travel to safe, effective and supportive spaces in Botswana would only improve health outcomes overall. Even if cultural imperatives to bear (multiple) children remain pervasive and the risks of navigating HIV exposures at home and 'on the road' persist but are navigable given the ubiquity of ARV therapies, then improving access and reducing transportation challenges through better infrastructures at the very least could help to improve health and wealth outcomes for all.

And lastly, one of the largest barriers to implementing equitable health policies to facilitate assisted reproductive technologies is the idea that infertility is not a pressing public health problem in the continent. Certainly, as a postscript, the surveillance of bodies and how and where bodies are moving have come under heightened scrutiny with the advent of COVID-19. What this means for female fertility migrants across southern Africa remains to be seen.

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Part V
Health Inequalities and Healthcare Planning

Chapter 20
Location, Accessibility and Socioeconomic Correlates of Child Immunisation Coverage in Nigeria

Ifeoma Evan Uzoma

20.1 Introduction

One of the cornerstones of Primary Health Care (PHC), child immunisation, is widely acknowledged as a successful method of lowering morbidity and mortality rates in children aged 0–5 years old (Uzoma, 2018; Shiyalap et al., 2004; Olorunsaiye & Degge, 2016; Oku et al. 2017). However, there are observable spatial variations in the immunisation coverage between and among locations, which are mostly linked to the context in which individuals reside and access healthcare (Olorunsaiye et al., 2016). Over the past 20 years, child and maternal death rates in Africa and Nigeria in general have been high (United Nations, 2021). This issue has served as the cornerstone for the introduction of other health schemes, including the Expanded Programme on Immunisation, which is one of the biggest social programmes in the nation (Uzoma, 2018).

Historically, the Expanded Programme on Immunisation (EPI) in Nigeria went through some phases before it became a success. The Expanded Programme on Immunisation (EPI) was initiated in Nigeria in 1979, 5 years after the universal launch, and was placed within the confines of the former Department of Public Health and Communicable Disease Control of the Federal Ministry of Health (FMH) (National Programme on Immunisation (NPI), 2004; WHO, 2014). Due to poor coverage, the first launch failed and it was later re-introduced in 1984 (Awosika, 2000). In 1996, it was renamed the National Programme on Immunisation (NPI), re-launched by the wife of the then Nigerian Head of State, Mrs. Maryam Abacha, following a review of EPI, Decree 12 of 1997 which created NPI as a parastatal. The NPI had the sole responsibility of supervising and enhancing routine immunisations

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in Nigeria (Awosika, 2000; WHO, 2014). One of the main thrust of the EPI was to reduce maternal and child deaths and other associated morbidities through the use of vaccines. The programme was also introduced to shrink the disparities in accessibility to health shaped by dividing variables such as place and wealth indicators.

The Expanded Program on Immunisation (EPI) was an idea propagated by the World Health Organization (WHO) to ensure that all children receive vaccinations against childhood and vaccine-preventable diseases (VPDs). The World Health Organization established the Expanded Programme on Immunisation (EPI) in 1974 to strengthen and broaden immunisation programmes around the world. By 1990, it was hoped that every child in the globe would be able to receive immunisations against diseases like diphtheria, pertussis, tetanus, poliomyelitis, measles and tuberculosis (Ophori et al., 2014). The EPI is made up of three main parts: surveillance for vaccine-preventable diseases (VPDS), rapid disease control and routine immunisation (RI). The routine immunisation component was the study's main focus.

Immunisation is a practical and affordable way to lower the morbidity and mortality of infectious diseases. Immunisation helps prevent more than two million deaths worldwide each year (Odusanya et al., 2008). Despite this, vaccine-preventable illnesses continue to be the leading cause of child mortality, accounting for an estimated three million deaths annually (WHO, 2009). Recent measles deaths have been significantly decreased by vaccination. Through supplemental immunisation programmes, more than 360 million children worldwide received the measles vaccine between 2000 and 2005. Additionally, advancements have been made in routine immunisation over this period and in the current time (Uzoma, 2018).

In the case of diseases like measles, the expected number of measles deaths worldwide has significantly decreased as a result of these expedited immunisation efforts. Between 1999 and 2005, measles mortality reduced globally by 60%. Africa saw the biggest improvements, with a nearly 75% decrease in measles infections and fatalities (WHO, 2007) and a further decline of 73% between 2006 and 2018 (WHO, 2019). As a result, there is a lot of pressure on medical facilities around the world to use vaccines to combat the disease. Indeed, the WHO's expanded immunisation campaign includes measles as a target disease (EPI). Children's health and survival are important advantages. The cost-saving benefit of immunisation stems from a decrease in disease incidence and fewer hospital or emergency room visits.

Although immunisation coverage in Nigeria has improved over the last decade (National Demographic and Health Survey, 2018), it is still comparably low. The proportion of children of ages 12–23 months who received all basic immunisation increased from 23% in 2008 to 31% in 2018. The proportion of children who did not receive the basic immunisations declined from 29% to 19% during the same period. While these developments show improvement, they still fall behind the Sustainable Development Goal 3 target, for which the target is achieving more than 90% coverage of all fundamental vaccinations among children age 12–23 months (NDHS, 2018). Also, inequalities in immunisation coverage rates are a problem across Nigeria as the NDHS (2018) indicated that the immunisation coverage rate varies significantly as it ranges from 5% in states such as Bayelsa, Kebbi, Sokoto and Zamfara to as high as 76% in states such as Lagos and Imo.

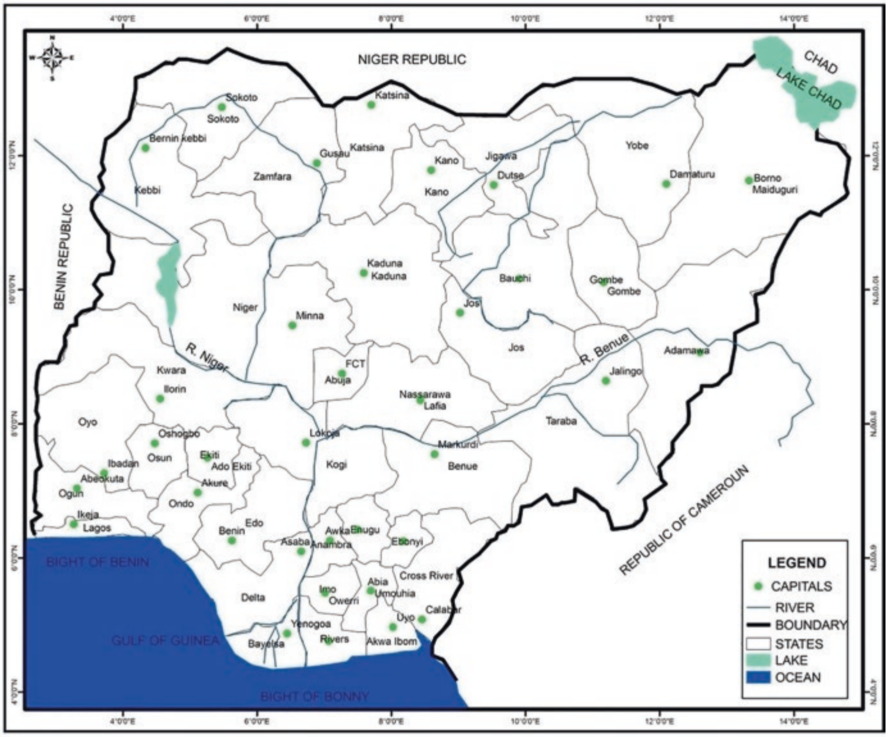

Fig. 20.1 Nigeria

Using a desk review of secondary data, this chapter looks at issues surrounding the low coverage of child immunisation in Nigeria within the geographical ambits of location, socioeconomic status and accessibility. Data employed were based on the 2018 National Demographic and Health Survey (NDHS), UNICEF data and other information as given by the World Health Organization. The NDHS was used because it is a representative picture of the situation in Nigeria. Nigeria, Fig. 20.1, has an estimated population of 206 million as at 2020 (GAVI, 2022). Infant mortality rate was 74/1000 and child mortality rate was 117/1000 as at 2019 (GAVI, 2022).

20.2 Immunisation Coverage in Nigeria

Immunisation coverage is one of the goals which the sustainable development goals 3 and 13 aim to achieve. In this light, the global vaccine action plan (2011–2020) was approved by 194 states to rightfully extend the benefits of immunisation to all people including women and children (WHO, 2017). However, it has been noticed that there are still gaps in immunisation coverage among countries especially the developing countries (Oryema et al., 2017; Uzoma & Ituen, 2017). Nigeria's immunisation coverage goal was 90%, but as at 2017, only 33% of the target had been reached (NICS, 2017) and by 2021, only 40% coverage had been reached (UNICEF, 2022). These statistics presents the picture of a slow growth in the use of immunisation. To shed more light on the coverage issue, it was seen that the Expanded Programme on Immunisation covers childhood vaccines such as polio, measles hepatitis B and other childhood diseases for children between 0 and 23 months, but the national statistics from the NDHS (2018) indicated that 40% of the children in Nigeria did not receive any vaccine from the health system. Furthermore, the statistics indicated that only 1 in 3 of the children examined received vaccines like Pentavalent, while 31% of the said children received the first dose but did not go further to get the other two doses. The national picture and Nigeria's situation, relative to the rest of Africa, are shown in Tables 20.1 and 20.2.

When the national figures are decomposed by States, vaccination coverage was highest in Anambra State (76%) and lowest in Sokoto State (5%). Other States with a relatively higher coverage, 59–76%, were Lagos and Imo. Alongside Sokoto State, Kebbi, Zamfara, Gombe and Bayelsa States also had the poorest coverage, less than 19%. The coverage by State is illustrated in Fig. 20.2. At the geopolitical regional aggregate level, States in the North-West region had the lowest coverage, Table 20.3.

In addition, the immunisation coverage data was also disaggregated to the regional level, and it was seen that the North West region had the highest percentage of not vaccinated children (61%), while the South East has the highest number of partially vaccinated children (48%) and the South West had the highest number of fully vaccinated children (50%). The figures align with the current situation on

Table 20.1 Coverage rate by vaccines

Vaccine	National coverage rate (%)	Africa
BCG	67	NA
Polio 0	55	NA
Polio 1	74	79
Polio 2	67	79
Polio 3	47	79
HepB (birth)	52	17
DTP-HepB-Hib 1	65	NA
DTP-HepB-Hib 2	58	NA
DTP-HepB-Hib 3	50	NA
Pneumococcal 1	62	19
Pneumococcal 2	54	19
Pneumococcal 3	47	19
IPV	53	79
MCV	53	47

Source: NDHS (2018) and UNICEF (2020)

Table 20.2 Immunisation coverage indicators for some vaccines in Nigeria and Africa

	Nigeria (%)	Africa (%)
First dose of Pentavalent (Penta 1)	49	83
Penta 3	33	74
Penta 1 and 3	31	11
Measles	42	72

Source: WHO/UNICEF Estimates (2017)

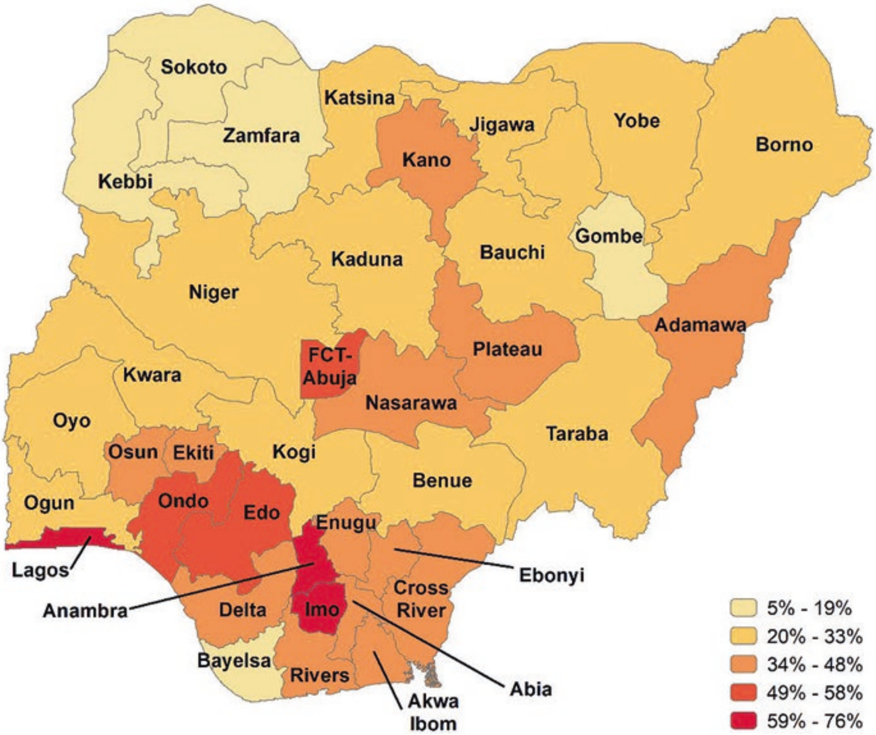

Fig. 20.2 Immunisation coverage by States. (Source: NDHS, 2018)

ground as the number of fully vaccinated children can be linked with the level of education of mothers in the region. The people of the South East region are known for their commercial resilience and there may be situations where people may start the immunisation process but may not be able to complete it as they may prefer to attend to their business ventures.

Table 20.3 Immunisation coverage by geopolitical regions of Nigeria

Region	Not vaccinated (%)	Partially vaccinated (%)	Fully vaccinated (%)
North-west	61	31	8
North-east	42	38	20
North-central	30	44	26
South-south	14	43	43
South-west	11	39	50
South-east	8	48	44
Nigeria	40	37	23

Source: Nigeria Immunisation Coverage Survey (2017)

20.3 Determinants of Immunisation Coverage

20.3.1 Location

The distribution of health components, such as immunisation, is influenced by location. Despite efforts by the WHO and governments to improve immunisation coverage, there is a persistent rural-urban differential in developing countries. For example, a study in India found a significant urban-rural disparity in immunisation rates, with only three states meeting the WHO target of 80% (Singh, 2013). In Africa, studies from countries like Uganda indicated that the location of health facilities affects utilisation of health services, as most are located in urban areas close to government headquarters rather than rural areas where people live (Magambo et al., 2020).

In Nigeria, children in rural areas are less likely to be vaccinated than those in urban areas, due to a lack of facilities. Official data on childhood vaccinations is scarce, but it is estimated that 38% of urban children are fully vaccinated compared to only 16% of rural children (NPC, 2008). A nationwide study on immunisation patterns in Nigeria found that 41.1% of children in urban areas were fully vaccinated compared to just 15% in rural areas. The study also revealed that the greatest urban-rural gap in vaccination was with the BCG vaccine, which is given at birth, reflecting a higher proportion of births in health care facilities in urban areas. However, the gap was smaller for the DPT3 and Polio3 vaccines (Adedokun et al., 2017).

Furthermore, in Northern Nigeria, immunisation rates are among the lowest in the world and the proportion of fully immunised infants is less than 1%. This results in many children becoming victims of vaccine-preventable diseases (Ophori et al., 2014). Additionally, data from the NDHS showed that more women in urban areas received the tetanus toxoid vaccine during pregnancy, indicating that health services are more available and utilised in urban areas. In the regional classification of women who received the vaccine during pregnancy, the south-east region had the highest rate at 84.1%, while the north-central region had the lowest at 31.3% as shown in Table 20.4.

Table 20.4 Uptake of tetanus toxoid vaccine by geo-political regions of Nigeria

Geographic region	Percentage of women who received tetanus toxoid vaccines
North-central	31.3
North-east	46.6
North-west	38.3
South-east	84.1
South-south	67.6
South-west	66.4
Nigeria	55

Source: NDHS (2018)

The northern part of the country is often seen as having lower vaccine uptake rates compared to the South, and this disparity can be attributed to a variety of factors such as economic conditions, disempowerment of women, religious and political views and misconceptions about vaccines. Additionally, the use of traditional herbs during pregnancy, which is not recorded, may play a role. Studies have shown that women in the South tend to be more educated, which is a major factor in determining vaccine usage as educated women are more likely to utilise health services (Uzoma, 2018; Uzoma & Ituen, 2017).

20.3.2 Accessibility

Accessibility is a crucial factor in vaccine coverage and is linked to both supply-related factors, such as proximity to vaccination facilities, availability of safe equipment and childhood immunisation services, as well as demand-related factors, such as a mother's knowledge and attitude towards vaccines (Antai, 2011). Bbriye et al. (2014) conducted a study in Uganda and found that even in urban areas with good physical access, there are still hard-to-reach populations and areas. Distance to vaccination facilities, wealth, place of delivery, missed vaccinations and poor distribution of immunisation services were cited as barriers to equitable coverage.

Proximity to health clinics, as a measure of accessibility, has been shown to impact vaccine coverage in Kenya (Ndiritu et al., 2006; Adedoye et al., 2017). Close proximity to a clinic is associated with a higher likelihood of vaccination, and coverage decreases with increasing distance from the clinic, as seen in Egypt (Reichler et al., 1998) and Pakistan (Reichler et al., 1997). This could be because a visible clinic may draw a parent's attention and serve as a reminder to vaccinate their child.

Ease of access to vaccines is influenced by geographical factors such as location and transportation systems. Central locations with good road networks and transportation systems make it easier for vaccines to reach users, while remote areas with difficult topography, such as highlands, marshy areas, and riverine communities, present challenges for vaccine delivery (Uzoma & Ituen, 2017). The travel time to

Table 20.5 Travel time to health facility

Travel time	Government health facility	Private health facility	Total
<30 min	16.9	26.0	18.7
30–60 min	20.4	8.9	18.1
>60 min	56.6	60.9	61.6
Don't know	5.9	4.3	5.6
Total	100	100	100

Source: NDHS (2018)

health facilities (Table 20.5) is also a factor in accessing health services, with results from the NDHS (2018) showing that women are more likely to attend health facilities that are more than 60 min away. This could be due to factors such as the quality of services, availability of specific services and the personnel at the facility. The results may also be influenced by the availability of such services at closer health facilities.

Access to health services involves both physical and financial considerations. The north-central region of the country primarily relies on motorcycles as a means of transportation to health facilities, as shown in Table 20.6, which was obtained from the NDHS report. This trend is also observed in the north-east, south-east and south-south regions, while private cars are the predominant mode of transportation in the north-west. In contrast, walking is the most common mode of transportation in the south-west. The mode of transportation affects travel time and is influenced by factors such as the environment, terrain and financial resources. Table 20.7 highlights that financial limitations are a significant barrier to accessing health facilities and vaccines. Although vaccines are provided for free, additional expenses such as transportation costs, food while waiting and other indirect costs pose a challenge. The distance to health facilities is longer in the north-central and north-east regions, which may be due to the large land area in these regions. Financial constraints are particularly problematic in the North East, which aligns with the region's high poverty rate, as reported by the NBS 2020 report.

20.3.3 Socioeconomic Status

The socio-economic status of a child's parents plays a significant role in their likelihood of being immunised. Children of parents in the lowest socio-economic quartile are almost twelve times less likely to be immunised than those from the highest quartile (Singh et al., 2013). This disparity can be attributed to various factors, including education, religion and communication (Lloyd et al., 2016; Oku et al., 2017; Singh et al., 2013). In a study by Adedokun et al. (2017), using data on children between 12 and 23 months in 896 communities in Nigeria, a positive correlation was found between mothers' education level and child immunisation. The study revealed that 31.1% of children whose mothers had secondary education were

Table 20.6 Means of transportation to health facility

Region	Private car	Taxi/ paid driver	Motorcycle	Public transport/ bus	Bicycle	Boat/ canoe	Walking	Ambulance
North-central	13.1	14.2	53.4	2.7	0.1	1.1	15.4	0.1
North-east	23.6	25.2	32.6	1.8	0.0	1.1	14.1	0.8
North-west	42.5	31.6	19.9	1.7	1.2	0.0	2.6	0.3
South-east	13.5	12.6	32.1	2.6	0.2	0.2	36.3	0.4
South-south	16.2	25.3	31.2	2.3	0.1	1.1	23.6	0.1
South-west	19.1	22.3	19.5	8.7	2.4	0.4	27.6	0.2

Source: NDHS (2018)

Table 20.7 Problems in access to health facility and vaccinations

Region	Problems			
	Permission from spouse	Financial constraints	Distance to health facility	No company
North-central	13.0	52.7	36.3	18.7
North-east	11.8	60.1	34	24.7
North-west	9.2	39.9	19.6	11.6
South-east	6.1	51.3	25.7	14.1
South-south	14.8	48.7	24.5	16.6
South-west	14.7	31.5	20.7	14.6

Source: NDHS (2018)

fully immunised, compared to just 3.9% of children who were fully immunised and whose mothers had no education.

In addition, mothers' social characteristics are one of the most well-known determinants of child immunisation. A study in southern Nigeria by Adedayo et al. (2009) found that mothers with lower education and those who were unemployed were less likely to complete their children's immunisations. Another study in Kaduna state by Taiwo et al. (2017) concluded that education empowers women to access relevant health services and receive information on prenatal care, childhood immunisations and nutritional needs. Maternal education has been deemed a significant determinant of child health, with a stronger impact than any other factor (Caldwell, 1979; Breiman et al., 2004). A study in Ghana by Daniel Buor (2002) also revealed a significant relationship between mothers' education level and children's vaccination patterns.

Household income also plays a major role in accessing care, as many indirect costs associated with immunisations, such as transportation to clinics, are more manageable for households with higher incomes (Sia et al., 2007). A study in Delhi, India, demonstrated that a secure, salaried job held by the head of the household was associated with a higher probability of children being immunised (Kasuma et al., 2010). These findings suggest that poor living conditions are not only associated with reduced immunisation rates but also with increased incidence of disease, putting additional strain on already weak health care infrastructure.

Studies in low-income countries (Aharona & Nichols, 2012; Altainkayanak et al., 2004) using qualitative analysis have found a correlation between living conditions and vaccination rates. In rapidly growing slum areas of low-income countries, access to health care services, including immunisations, is limited, contributing to a high burden of infectious diseases and spreading infections to other communities (Kusuma et al., 2010). A higher quality of roofing was positively associated with overall vaccination rates in Delhi, India, and with higher measles immunisation rates in Lasbella district, Pakistan (Mitchell et al., 2009), suggesting that families with better housing are more likely to have their children immunised.

The supply of vaccines is also an important factor in immunisation. Eboreime et al. (2015) compared supply determinants in one low-income area in the north and south and found that supply-related factors are important, though a sufficient supply of vaccines does not necessarily guarantee that children will be vaccinated. Several studies have shown that factors affecting vaccine demand and acceptance are even more complex (Jheeta & Newell, 2008; D'Onofrio et al., 2010), highlighting the need to eliminate inequities associated with norms and structural factors that may prevent increased vaccination uptake. Other factors that can influence immunisation coverage among children include maternal characteristics, the sex of the child, birth order, place of delivery, follow-up antenatal care, wealth index, knowledge about vaccination.

20.4 Challenges of Non-utilisation

The utilisation of vaccines is a critical aspect of vaccine coverage. Without proper use, even if vaccines are available, the entire process becomes ineffective. Despite reported advancements in immunisation and its numerous benefits, Nigeria is still facing difficulties in reaching its immunisation coverage goals and combating vaccine-preventable diseases. The challenges faced by immunisation efforts include, but are not limited to, insufficient funding for vaccination programmes, which mostly come from external donors, opposition due to religious beliefs and misconceptions about vaccine safety, and accessibility problems (Paediatric Association of Nigeria (PAN), 2022). According to the NDHS data, the primary reason for not utilising vaccines is a lack of awareness, while family-related issues such as a lack of time and household responsibilities are the least common factors (Table 20.8).

The funding of immunisation and other health services primarily by external donors makes it challenging to consistently supply vaccines. Additionally, supply chain breakdowns can result in missed opportunities and vaccine shortages, as well as postponed vaccination days. Other barriers to full immunisation coverage include

Table 20.8 Reasons for not utilising vaccination

Reasons	%
Lack of awareness	42
Mistrust or fears	22
Service delivery issues, e.g., distance and time	25
Family issues	18

Source: NDHS (2018)

strikes among health workers, political and religious opposition, misconceptions, misinformation, security issues and logistical difficulties in transportation and storage. Beyond funding shortfalls, other problems include delays in funding releases, inefficient use of funds, accountability problems, non-sustainable financing by donors and poor coordination.

The failure to fully utilise vaccines results in waste and increased service costs. Two types of waste are identified: system waste and service (administrative) waste. Due to disparities in data on vaccine supply, usage and immunisation numbers, there is a high likelihood of buffer stock and carry-over of excess supplies. This is further complicated by some states reporting negative vaccine waste rates. The costs associated with vaccine waste are substantial, totalling US$2.6 million for basic EPI vaccines and US$0.683 million for other routine vaccines. These estimates highlight the financial impact of vaccine waste and its negative impact on the cost efficiency of the national immunisation programme.

20.5 Conclusions

The third pillar of the Sustainable Development Goals is health, and immunisation is a crucial component of this. Immunisation has been said to contribute to 14 out of the 17 goals (Decouttere et al., 2021). It plays a significant role in reducing disease burden, protecting against infectious diseases, addressing poverty, hunger and promoting sustainable cities. As a result, access to primary health care, nutrition services, education, gender equality and reduced inequalities depends on vaccination services. A healthy population leads to the development of manpower, innovation, infrastructure, institutions and partnerships.

Nigeria can improve its immunisation efforts to reduce maternal, child and infant mortality and the spread of diseases. Improving the health of the population is key to the overall development of a region, and making health care services widely available will act as a catalyst for the development of the country. Full immunisation coverage can be achieved by addressing socio-demographic and risk factors in affected areas. Prioritising intervention and focusing on location-specific strategies, such as providing immunisation session reminders and engaging community and religious leaders in education efforts, will help improve coverage. Re-establishing outreach centres in rural areas will also aid in expanding immunisation efforts in Nigeria.

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Chapter 21
Approaches to Defining Health Facility Catchment Areas in Sub-Saharan Africa

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21.1 Introduction

A health facility catchment area (HFCA), also known as a sphere of influence, tributary area, service area or demand field, represents a geographical area around a health facility describing the majority population that uses its services (Iyun, 1983; Macharia et al., 2021). A HFCA is needed to define the catchment population

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(denominator), which is essential for disease mapping, optimising timely routine and emergency access, immunisation campaigns and vaccination programmes, distribution and allocation of essential health commodities and planning the location of a new health facility (Airey, 1992; Alegana et al., 2020b; Criel et al., 1996; Gething et al., 2004; Macharia et al., 2017, 2022; Sturrock et al., 2014). Therefore, knowledge of HFCAs is important for efficient healthcare planning and resource allocation within a population (Kloos, 1990).

Defining a representative HFCA is non-trivial (Okiro et al., 2011). Its definition is substantially dependent on the availability of geo-positioned residential addresses of patients linked to the sought facility and robust data on their health-seeking behaviour. The healthcare-seeking behaviour is influenced by socio-economic, cultural and religious factors, transport systems, weather patterns and the characteristics of facilities such as size, services offered, stock-outs and competition from other health facilities (Gething et al., 2004; Iyun, 1983; Macharia et al., 2021; Okiring et al., 2021a). However, in the majority of sub-Saharan Africa (SSA) and other low-resource settings, such data are not readily available due to limited resources in the context of many competing needs (Macharia et al., 2021). The problem is more pronounced in rural poor settings where formal address systems are almost nonexistent (Stresman et al., 2014). In addition, privacy concerns may limit the use of precise spatial locations for the residential address of the patients (Stresman et al., 2014; Warren et al., 2016).

As a result, reliable HFCAs have not been adequately defined by the Ministry of Health (MoH) (CartONG, 2019; Macharia et al., 2021; Okiring et al., 2021a) which hampers routine planning and surveillance (Okiring et al., 2021a). Current attempts have involved the use of the most fundamental data (health facility location and a set of simple auxiliary factors) to define HFCA (Gething et al., 2004) using a range of simple-to-complex approaches. However, these approaches are conveniently implemented, disregarding the implications of the defined HFCA on the accuracy of the catchment population and consequences for public service planning. To date, there has been no review of approaches that have been used to define HFCA in SSA to harness the best practices and innovations in defining a closer-to-reality HFCA. In this chapter, we review approaches that have been used to define HFCA in SSA while documenting their pros and cons. We conclude by proposing a pragmatic approach based on the best practices of published literature that can be applied in the SSA context.

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21.2 Methods

Our review followed updated guidelines from the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (Page et al., 2021).

21.2.1 Search Strategy

To identify eligible papers, a comprehensive search strategy was developed under the guidance of an information and library expert and a group of spatial epidemiologists. First, we developed a search strategy that leveraged the unique search optimisation features and indexing of each of the three electronic databases: PubMed, Scopus and Cumulative Index to Nursing and Allied Health Literature (CINAHL). The final literature search was conducted in April 2022. The main search terms were HFCA and its synonyms such as hospital catchment, health service area, facility service area combined with defining/creation/modelling/estimation/delineation/planning and the list of SSA countries. Boolean operators and asterisks were used to optimize the search process. We also screened the bibliography of the selected papers for additional papers. We used Mendeley and Rayyan to serve as bibliographic software for managing references in the review.

21.2.2 Eligibility Criteria

The review sought to identify studies that were closely related to the measurement and conceptualisation of HFCA in any SSA country. We did not limit the search by year; therefore, all years were included in the review. We excluded reviews, editorials and conference presentations but included any relevant studies from their bibliography. We screened the identified studies in three stages: (1) screening by title, (2) screening by abstract and (3) screening by reading the full text. Two authors independently reviewed all abstracts and full-text formats of the studies while a third author was used to resolve discordances. After screening, data were extracted from the remaining studies.

21.2.3 Data Extraction

An online data extraction form was developed to obtain information about HFCA models and other important study characteristics. These characteristics were (1) bibliographic information, (2) facility level, (3) health or study outcome, (4) analytical method used to define HFCA, (5) data needed to define HFCA, (6) sensitivity analysis (7) and modelling gaps and recommendations that were acknowledged by the authors. Extraction discrepancies were resolved by consensus and by an independent arbitrator.

21.2.4 Data Synthesis

Given the large scope of the review and the heterogeneity of the studies reviewed, a meta-analysis was not appropriate. However, a qualitative synthesis was conducted to identify approaches and methodological commonalities across studies and contexts.

21.3 Result

Overall, we retrieved 808 articles which were exported to the Mendeley Reference Manager. Studies were screened and excluded by title, abstract and full text. Studies excluded after full-text review did not explicitly define an approach to model HFCA. Ultimately, 83 peer-reviewed articles met the inclusion criteria (Fig. 21.1). The earliest manuscript was published in 1977 while the majority of the studies (84%) were published after 2008 with 2020–2021 contributing 30% of all the

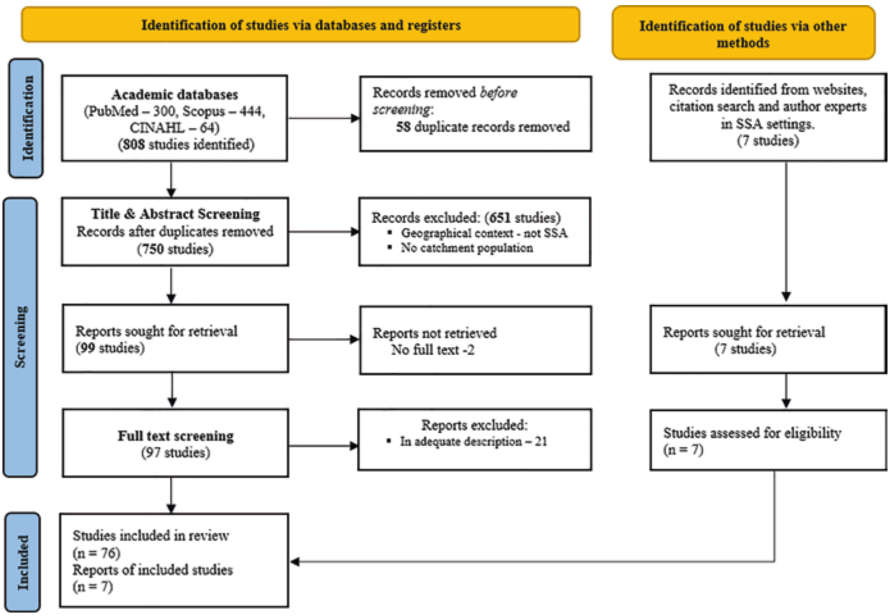

Fig. 21.1 Flowchart for study selection from literature search to data extraction and analyses

studies. The studies varied by geographical scale and scope. Four studies (5%) were conducted across multiple countries whereas 79 studies (95%) were conducted within 21 individual SSA countries. Kenya (16%), Uganda (13%) and Zimbabwe (10%) had the highest number of studies while nine countries each had at most two studies.

The studies were evenly distributed across the health system hierarchical structure, focusing on either primary (28.9%), secondary (33.7%) or both tiers (37.3%). The main health outcomes across the studies were highly variable. We identified 22 different health outcomes, with malaria (26.5%), HIV (15.7%), healthcare utilisation (15.7%), vaccination (6.0%) and maternal and newborn care (6.0%) featuring in 70% of the manuscripts. Table 21.1 summarises data, threshold used to delineate HFCA, limitations (where indicated) and approaches, which have been used to define HFCA across the last four decades in SSA.

The use of subnational administrative boundaries (e.g. wards) to define HFCA was the second most common approach (21 studies). The boundaries of a polygon in which a facility was located and sometimes the neighbouring polygons formed the HFCA. Boundaries were used either independently or in combination with defined urban areas, disease estimates and population count or allocated by the MoH. The location of the health facility and the administrative boundaries combined with auxiliary datasets were the minimum dataset required. However, this approach ignores cross-border movement, and migration in and out of the catchment over time, particularly in rural areas where alternatives are limited.

Buffers around a health facility defining HFCA require the location of the health facility as the only input. Due to this simplicity, it was the most common approach (24 studies) including those that refined the buffers using population, administrative boundaries or road networks (Table 21.1). The buffer size was based on a pragmatic distance that captured most patients or thresholds derived from literature, household surveys, local or international practices, facility level/function and locality (urban or rural). The use of buffers was criticised because it is based on unrealistic straight-line distances which do not account for topography, transport modes, seasonality, mobility of people, the attractiveness of facilities, the inability of sick people to walk and documented healthcare-seeking behaviour (such as bypassing the nearest facility). The authors justified the approach given the lack of updated data, especially healthcare-seeking behaviour data.

Closely related to the buffers is the use of Thiessen polygons, also known as Voronoi diagrams, to define HFCA (four studies). They define a region incorporating all points that are closer to a given facility than any other facility, have similar data requirements and limitations as the buffers and can be combined with other approaches (Table 21.1). The need to account for the variable per-capita utilisation rate within the HFCA was an additional limitation that was highlighted.

To account for some of the limitations in the use of administrative areas, buffers and Thiessen polygons, in defining HFCA, 20 studies applied a threshold on modelled travel time/distance to define a slightly improved HFCA. Time or distance was modelled through the path of least resistance via network analysis or cost distance surface accounting for transport mode, speeds, travel barriers (game park, reserves,

Table 21.1 Summary of methods used to generate health facility catchment areas in sub-Saharan Africa including required datasets and limitations of the approaches

Methods used to define HFCA	References	Time/distance threshold	Minimum data required	Gaps that were acknowledged
Administrative *boundaries* such as wards and sectors or merged units such as EAs assumed to be HFCA	Buzdugan et al. (2015, 2016), Chipwaza and Sumaye (2020), Emmanuel et al. (2015), Kigozi et al. (2019), Koyuncu et al. (2019), Krumkamp et al. (2012), Marks et al. (2017), McCoy et al. (2016), Mugambe et al. (2021), Peters et al. (2020), Poletti et al. (2018) and Sudhof et al. (2013)	Polygons in the neighbourhood of the facility or preselected by MoH	Administrative boundaries Health facility Residential address Disease estimates Spatial extents of a city or urban area	Cross-border movement and migration of people are not accounted for Unrealistic in rural areas with poor and limited access Ecological bias Use of a static catchment over time
Bounded urban area – a whole city or partly defined by sector or suburbs	Bertolote et al. (2005) and Mboup et al. (2018)	Area bounded by an urban area		
Disease estimates within administrative *boundaries* showing regions with a high number of cases	Alegana et al. (2020a), Beyene et al. (2021), Centers for Disease Control and Prevention (CDC) (2013) and Zinszer et al. (2014)	Cumulative case ratio, the highest number of cases often 80%, admission rates		
Administrative *boundaries*, villages or populations allocated by MoH to a health facility	Arambepola et al. (2020), Buzdugan et al. (2015, 2016), Kruk et al. (2014) and Paireau et al. (2014)	Villages, wards or populations allocated to clinics by the MoH		

Buffers ranging from 1 to >50 km drawn around a health facility sometimes augmented by population	Ashiagbor et al. (2020), Atela et al. (2015), Chakraborty et al. (2016), Gonese et al. (2010), Haidari et al. (2017), Hensen et al. (2015a, b), Kamau et al. (2020a), Lori et al. (2018, 2019), Montana et al. (2008), Musinguzi et al. (2009), Njuki et al. (2013), Ochoa-Moreno et al. (2020), Okiro et al. (2011), Parker et al. (2010), Peters et al. (2020), Stresman et al. (2014) and Walker and Gish (1977)	Informed by facility level, function, urban or rural, capturing a majority of patients, pragmatic or reasonable distance, previous cut-offs, based on a household survey, local or international practices, for example, WHO threshold	Health facility, residential address population, transport factors and barriers and boundaries	Straight-line distances are unrealistic because they do not account for topography, transport modes, the likelihood of a person living beyond a time threshold, lack of updated spatial and healthcare-seeking behaviour data, the inability of sick people to walk, facilities are not uniformly attractive to all patients and clients, seasonal mobility of people, bypassing of the nearest facility and the catchment is not a function of distance only
Radial *buffers* accounting for geographical barriers, enumeration or parish boundaries and road networks	Doherty et al. (1996), Kamau et al. (2020b, c), Mpimbaza et al. (2020) and Zinszer et al. (2014)			

(continued)

Table 21.1 (continued)

Methods used to define HFCA	References	Time/distance threshold	Minimum data required	Gaps that were acknowledged
Thiessen polygon, a region incorporating all points that are closer to a given facility than any other	Farber et al. (2017), Gething et al. (2004), Kundrick et al. (2018) and Pattnaik et al. (2021)	All points that are closer to a given facility than any other	Health facility and coarse residential location	Straight-line distances are unrealistic, bypassing the nearest facility, does not account for transport modes, healthcare-seeking behaviour and other factors beyond distance and per-capita utilisation rate is constant within the HFCA
Thiessen polygon with *boundaries*, travel factors, *buffers* and population	Okiro et al. (2013)			

Modelled travel time or *distance* based on a least-cost path model or on network analysis often adjusted for facility capacity, population, Thiessen polygon, boundary or residential addresses	Alegana et al. (2012), Aoun et al. (2015), Arambepola et al. (2020), Bailey et al. (2011), Brunie et al. (2020), El Vilaly et al. (2021), Epstein et al. (2020), Huerta Munoz and Källestål (2012), Kigozi et al. (2020), Macharia et al. (2017), Manongi et al. (2014), Nyandwi et al. (2017), P. O. Ouma et al. (2017), Palk et al. (2020), Ray and Ebener (2008), Stassen et al. (2018), Stresman et al. (2014), Sturrock et al. (2014) and Tansley et al. (2015, 2016)	Based on care utilisation decay curve, recommended thresholds by MoH or international community, previous publications	Health facility, travel factors and barriers, population, residential location, household survey, facility capacity, boundaries and seasonality	Account for bypassing of the nearest facility, facility type and ownership, quality of service, referral, urbanity, care-seeking behaviour, the severity of illness, seasonality, other dimensions of access, supply and demand factors, resources and infrastructure changes over time, local speeds, traffic, overlaps in HFCA, realistic distribution and use of public transport. Better data is needed to test model assumptions. A trade-off between model complexity and precision
Participatory GIS with auxiliary data and patient addresses	Ansumana et al. (2010), Borgdorff and Walker (1988), Oteri et al. (2021) and Stresman et al. (2014)	Patients identify their addresses from maps or interviews with long-term residents or health staff	Participants, maps, health facility, list of place names and population	Expensive to acquire high-resolution satellite imagery and incompleteness of spatial data

(continued)

Table 21.1 (continued)

Methods used to define HFCA	References	Time/distance threshold	Minimum data required	Gaps that were acknowledged
Patient's address linked to the utilised facility or refined with *boundaries, disease* rates and *population*	Airey (1992), Barker et al. (2002), Clur (2006), Criel et al. (1996), Iyun (1983), Kloos (1990), Okiring et al. (2021a, b) and Okiro et al. (2009)	Over 90% of all admissions, all addresses linked to the utilised facility	Health facility linked to residences, base map and travel factors	Poor record keeping, the credibility of reported distances and bypassing of facilities by those who live far. Limiting within a region
Two-step floating catchment area combined with patient address and gravity models	Page et al. (2021), Tansley et al. (2016) and Wilson and Blower (2007)	Considers interaction between supply and demand	Facility, urban residence, travel factors, population and capacity	Account for variations in the mode of transport, road conditions, times of travel, traffic, travel behaviours, speeds, utilisation rates and navigation errors
Spatial statistical models based on admission rates or reporting probabilities or the use of fuzzy choice	Alegana et al. (2020a), Gething et al. (2004) and Nelli et al. (2020)	EAs contribute to HFCA with varying likelihood based on the proportion attending a facility or reporting probability	Health facility, residential EA, spatial factors that affect travel and admissions	Account for competition, population mobility, socio-demographic factors, care-seeking behaviour, geocoding inadequacies, cases not seen at a facility, realistic transport modes and non-governmental facilities

water bodies and forest), travel factors (road network, land cover, topography) and sometimes simplified healthcare-seeking behaviour. In some instances, modelled time was adjusted for facility capacity and population or used in combination with Thiessen polygon, boundary or residential addresses (Table 21.1). The choice of the threshold was based on previous publications, policy recommendations by MoH or the international community or the use of a utilisation decay curve.

Despite accounting for some limitations, drawbacks of modelled travel time/distance to define HFCA exist. Authors recognised the need to better account for care-seeking behaviour (bypassing the nearest facility, severity of illness, other dimensions of access, localised speeds, traffic, weather seasonality, urbanicity, realistic distribution and use of public transport, resources and infrastructure variation over time), supply-side factors (facility type and ownership, quality of services at facilities, referral patterns) and overlapping of two or more HFCAs. Further, the authors argued that better data are needed to test model assumptions while balancing the trade-offs between model complexity, precision and routine application.

Albeit minimal, four studies used public participatory Geographical Information System (GIS) approaches. This involved community members and the patients defining HFCA, for example, through data collection. Patients would identify their residential addresses from maps presented to them during health facility visits or interviews with long-term residents of an area or health staff to map HFCA. The main requirements were the participants, maps, imagery or a list of place names of the area. The approach was limited given the cost associated with acquiring high-resolution satellite imagery of the area and the incompleteness of existing spatial data.

On the other hand, the use of geocoded patient addresses (nine studies) linked with the health facility provided the most representative catchment area. The patient's addresses were available at different spatial resolutions and were often refined or combined with boundaries, disease rates and population. However, poor record keeping, bypassing of facilities, limiting the catchments within a region and the credibility of reported distances were reported as limitations.

Finally, to advance the approaches using modelled travel time, there were six standalone efforts to derive HFCA based on two-step floating catchment area (Stewart et al., 2020; Tansley et al., 2016), gravity models (Wilson & Blower, 2007), spatial-statistical (Alegana et al., 2020a; Nelli et al., 2020) and fuzzy choice models (Gething et al., 2004). Mainly, these approaches had residential areas or enumeration areas contributing to HFCA with varying degrees of likelihood based on several factors (Table 21.1). Despite having some improvements, they did not satisfactorily account for variations in travel (mode of transport and speeds, road conditions, time of travel, traffic conditions, navigation errors), utilisation rates and care-seeking behaviour, competition between facilities, population mobility, socio-demographic factors, geocoding inadequacies, cases not seen at a facility and non-governmental facilities.

Across the studies, a range of techniques were implemented as sensitivity analyses for the derived HFCA. These included deriving several HFCAs for the same study area while using different (i) methods (Farber et al., 2017; Peters et al., 2020;

Zinszer et al., 2014), (ii) assumptions on healthcare-seeking behaviour (Arambepola et al., 2020), (iii) population thresholds (Ansumana et al., 2010), (iv) travel speed (Stewart et al., 2020; Tansley et al., 2016), (v) radii for the buffer approach (Haidari et al., 2017; Tansley et al., 2015), (vi) several teams validating the generated HFCA (Oteri et al., 2021) and (vii) using information criterion to select the best statistical model (Alegana et al., 2020a). Finally, AccessMod and ArcMap were the most used softwares to derive HFCA. Other softwares included QGIS, Google Earth, GeoDa, Epi Info, R, STATA, FoxPro and SAS.

21.4 Discussion

The review has outlined approaches that have been used to define HFCA in SSA, a largely resource and data-constrained region. These approaches either rely on or are associated with techniques of defining geographical access as summarised in P. Ouma et al., (2021). Overall, in SSA, there is a scarcity of geocoded data on patients' residential addresses linked with the facility where care was sought which is the gold standard in defining a HFCA (Table 21.2). As a result, only six studies utilised such data (Airey, 1992; Barker et al., 2002; Clur, 2006; Criel et al., 1996; Iyun, 1983; Kloos, 1990; Okiring et al., 2021a, b; Okiro et al., 2009), while six other studies either relied on MoH-derived HFCA (Buzdugan et al., 2015, 2016; Kruk et al., 2014) or used participatory GIS to collect data needed to delineate spatial extents of HFCAs (Ansumana et al., 2010; Borgdorff & Walker, 1988; Oteri et al., 2021; Stresman et al., 2014). The rest of the approaches used a variety of methods, with varying degrees of representativeness to delineate HFCA.

Three commonly used approaches, administrative boundaries, buffers and Thiessen polygons, are limited because they oversimplify socio-demographic, epidemiological and health-seeking characteristics of communities when deriving

Table 21.2 Choice of method in generating health facility catchment areas in sub-Saharan Africa and low-resource settings

Proposed level	Approach	Notes
Level 3: Least appropriate	Thiessen polygons, administrative boundaries and buffers	Oversimplified assumptions which are unrealistic in terms of healthcare-seeking behaviour and health system characteristics. Thus, it should be rarely used unless results are aggregated to large subnational units.
Level 2: Moderately appropriate	Modelled travel time and distance while accounting for key factors and balancing between model complexity and programme use	Should robustly account for healthcare-seeking behaviour, realistic transport systems, demand and supply side of a health system.
Level 1: Most appropriate	Geocoded residential address of a patient linked to the utilised health facility at a high spatial resolution	High spatial resolution patient residential addresses with their journey experiences and outcome within the health system should be well documented.

HFCA (Table 21.1). These inadequate approaches will thus result in a non-representative catchment population, and therefore, their use should be discouraged (Table 21.2). However, these approaches might be useful for applications that aggregate results to large subnational units. For example, a catchment derived using Thiessen polygons, but results presented at a district level. On the other hand, approaches based on travel time, gravity and spatial statistical models while useful also still require novel extensions to deal with their shortcomings (Table 21.1) to push the frontier to the next level. The advances should be widely accessible at the programmatic level for routine use.

The key aspects that should be considered to open up a new avenue for HFCA definitions are cross-cross-border movement and overlapping catchments, mobility of patients, realistic travel times (which account for weather seasonality, transport modes within the public and private sector, localised speeds, road conditions, traffic, time of journey and navigation errors), competition between facilities, health-seeking behaviour (bypassing of the nearest facility, socio-demographic factors, severity of illness, cases not seen at a facility), facility characteristics (type and ownership, quality of service), residence (urban or rural) and referral patterns.

To account for these aspects, better data will be needed. This will also aid in testing model assumptions and deal with the perennial incompleteness of spatial data, poor record keeping and geocoding inadequacies (Delmelle et al., 2022). With the advancement in data science (such as machine learning) and data collection techniques (such as remote sensing), a range of climatic and environmental data (e.g. land use, rainfall patterns), road networks and traffic patterns can now be easily collected (Herbreteau et al., 2007; Nachmany & Alemohammad, 2019). Increasingly available household surveys and routine data will be valuable for tracking utilisation rates in the population to derive better thresholds for different health outcomes and contexts. Further, the use of mobile phones has become ubiquitous across the globe and can be harnessed to record geographical location information, especially in SSA to improve HFCA definition (Woods et al., 2022). However, privacy and data protection concerns will need to be considered when utilising data from mobile phones. This is also a challenge affecting sharing of patients' addresses and locations of service providers in the routine health information systems in SSA.

The travel time or distance thresholds that patients can travel are critical in the delineation of HFCA irrespective of the complexity of the approach. The threshold varies depending on the local context, health condition, severity of illness and services offered at a facility. The use of healthcare utilisation data for a particular outcome to create a decay curve or medical relevant thresholds is more useful than random and generalised thresholds. It is probably the use of random thresholds, cross-border movements and simplified approaches (administrative boundaries, Thiessen polygons or buffers) that may have led to health coverage exceeding 100% at the facility level in recent DHIS2 analyses (Gesicho et al., 2020).

We, therefore, propose three levels when choosing an approach to delineate HFCA guided by the data availability and study objectives (Table 21.2). *Level 1* is the most appropriate approach where HFCA can be defined unambiguously. It will require patients' addresses to be geocoded and linked with the service provider where care was sought and where possible to harness recent technologies to collect these data. The second level (*Level 2*) is based on travelled time or distance but requires innovative methods to deal with the outlined key shortcomings. Finally, *Level 3* is the least recommended and its use is discouraged due to unrealistic assumptions.

Further MoH-derived HFCAs should be available across countries in SSA as a fundamental baseline for healthcare planning. However, limited studies referenced the use of MoH-derived HFCA, which may imply the absence of guidelines within MoH on defining robust HFCA. This may be attributed to poor documentation or that the role of HFCA is underappreciated. In this line, though at nascent stages, it is a promising initiative aiming to create a system that enables MoH and stakeholders to define, create and manage their HFCA (Herringer, 2021).

Much of SSA and other low-resource countries are currently striving to achieve the ambitious targets within the Sustainable Development Goals (SDGs) framework by 2030. The SDG mantra of *leaving no one behind, and reaching those farthest, behind, first* would require estimating the populations in need of essential health services and defining healthcare coverage gaps at the HFCA level for targeted resource location. This will be essential for universal health coverage (UHC) to ensure that all people have access to the health services they need, when and where they need them, without financial hardship. Therefore, the role of accurate HFCA is timely and cannot be ignored as *a catalyst for health development in SSA*. In addition, the concept of a catchment area extends beyond health facilities, and similar cases (limitations and requirements) may be advanced for catchment areas related to schools (Macharia et al., 2022), community health workers and vaccination posts among other service delivery points (Macharia et al., 2021).

The review should be interpreted while considering several limitations. The literature search was limited to studies published in English. Secondly, given the vast nature of grey literature, some insights on HFCA in SSA might have been missed, and our findings can only be applied to SSA countries or similar contexts. Despite these limitations, the review shows that most of the studies derived HFCA using simplified approaches due to a lack of appropriate data. To move the frontier of HFCA to the next level, the majority of the limitations that were acknowledged should be accounted for to derive closer-to-reality HFCA for robust catchment populations (denominator) for healthcare planning.

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Chapter 22
Access to Health Facility and Frequency of Antenatal Care Visits in Malawi Using Bivariate Copula Regression Modelling

Ellen Gondwe, Michael G. Chipeta, and Lawrence N. Kazembe

22.1 Introduction

Utilisation of health services has long been recognised as a fundamental tenet of wellbeing and promotes positive health outcomes in a population (WHO, 2010). Accessibility of health services has been shown to be an important determinant of utilisation of health services (Shah et al., 2016; Kuuire et al., 2017). Distance to health facilities, rurality and the need for care are among the common factors related to accessibility of health care. Increased distance inhibits access and frequency of utilisation.

Although access can be measured in many ways, geographic access is said to be a concern in many rural areas as people who live in hard to reach areas find it difficult to contact health care personnel (Arcury et al., 2005). In developing countries, where health facilities are far and few, adequate and timely access to health care is a huge public health challenge (Gebremeskel et al., 2015). Evidence shows that developing countries bear a disproportionate burden of diseases because of inequitable utilisation of health care (Haruna et al., 2019). In most rural areas in Africa,

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one in three women lives more than five kilometres from the nearest health facility (Yao & Agadjanian, 2018).

This aspect of health care is critical for women's access to ANC services. Both timing and frequency of ANC services depend on distance, which is fundamental for improved maternal and child health outcomes. If health services are not accessible, it is likely that there will be unmet need for health care. For instance, the main component of ANC services is to provide information and advice to women about pregnancy-related complications and possible corrective measures upon early detection (Gupta et al., 2014; Kuuire et al., 2017). In addition, antenatal care raises awareness about the need for care during delivery; hence, timing of the first visit is vital for better health outcome of the baby and mother (Kuuire et al., 2017). For so many years, there has been inadequate utilisation of antenatal care services in developing countries (Rustagi et al., 2021; Islam et al., 2022; Nxiweni et al., 2022) across the world, Malawi inclusive (Mamba et al., 2017; Mchenga et al., 2019). Despite the introduction of free ANC services by the Government of Malawi in 2004, the level of utilising ANC equally is still low in the country (National Statistical Office-NSO/Malawi and ICF, 2017). Many researchers have investigated several factors associated with the use of antenatal care content (Ye et al., 2010; Edward, 2011; Ajayi & Osakinle, 2013). Main factors influencing the utilisation of antenatal care services include maternal education, maternal employment, age, poverty and access to the media. A few studies have looked at access to HF and frequency of utilisation of antenatal care service. For example, studies done in Nigeria, Ethiopia and Malawi (Gebremeskel et al., 2015; Kuuire et al., 2017) only considered the general determinants of access to antenatal care services. In additional, these used descriptive summaries and logistic regression to determine the factors and ignored possible correlation between the two outcomes- access and frequency of visits.

Moreover, spatial health accessibility as determined by the availability and location of healthcare facilities as well as the location of people has not been fully investigated in countries such as Malawi (Shah et al., 2016). Geographical disparities within a country still remain a hindrance towards access to maternal health care. The poor and people living in hard-to-reach areas tend to have worst health status and poor access to professional health services (Kuuire et al., 2017). This has profound impact as failure to initiate ANC early may lead to complication and low attendance of ANC during the pregnancy period (Gebremeskel et al., 2015). In Malawi, most people live in rural areas where healthcare services are very poor and their access to these services is invariably very low since most of the health facilities are far from the people's locations.

The ability to access antenatal care services makes it easier for pregnant women to fully utilise the services provided as it enables interaction between them and the healthcare providers. However, spatial accessibility to health care facility is still an issue due to the non-uniform distribution of healthcare facilities, which in the end leads to low utilisation of health care (Jin et al., 2015; Khakh et al., 2019). Modelling access and utilisation of ANC has received much attention in health policy planning, health economics and public health in general. A very common approach is based on independent models, for instance, a logit model for access to HF or early ANC and another logit for whether at least four ANC visits have been made (Seidu, 2021; Yehualashet et al., 2022). In some instances, a discrete outcome model, for example, Poisson, has been used to analyse the number of ANC visits (Gayawan, 2014; Bekalo & Kebede, 2021). The main assumption in such analysis is that the two outcomes are independent, which largely is misleading or untenable. As it is, statistically, this presents an interesting research question because these are mixed dependent outcomes which are better handled using joint analysis.

Having difficulties to access antenatal care services mostly leads to low utilisation of the services, implying the two outcomes are intrinsically dependent. As such joint modelling of frequency of antenatal care visit and travel times, which captures access to the nearest health facility, including geographical location of the women, is necessary. To perform joint spatial modelling at district level, copula modelling is applied to account for spatial dependency and spatial distribution. Joint analyses are found in many applications in public health. The aim of the study is to investigate how access to HF affects the number of ANC visits a woman had in her entire pregnancy period. This chapter proposes a joint model for the correlated discrete and continuous outcomes constructed using copulas (Oakes & Ritz, 2000), extending previous work done that considered timing and frequency of ANC utilisation (Kazembe, 2019; Gondwe et al., 2022).

22.2 Data

The study used a combination of two data sources: first, that of women's health seeking behaviour for antenatal care (ANC) services and second that of access to HF-calculated as travel walking time to the nearest health facility. These are explained in detail below.

22.2.1 ANC Data Sources

The study used secondary data from the 2015/2016 Malawi Demographic Health Surveys (MDHS), which was collected by the Malawi National Statistical Office and the Malawi Ministry of Health. Permission to use the data was granted by the Measure DHS programme (https://dhsprogram.com/data/available-datasets.cfm).

The 2015/2016 MDHS used a two stage sampling process. In the first stage, 850 standard enumeration areas (SEAs) were selected in 173 urban and 677 rural areas (stratum or SEAs) using a probability proportional to the SEA size. In the second stage, 30 households per urban cluster and 33 per rural cluster were selected with an equal probability systematic selection from the newly created household listing. All women aged 15–49 years who were either permanent residents of the selected households or visitors who stayed in the households the night before the survey were eligible for interviews. The final sample was 9228 women. Data includes demographics, social economic determinants and location. The data includes GPS coordinates information of all the clusters included in the survey. All women residing in the same cluster have the same geo-referenced location. To protect the confidentiality of DHS survey respondents, the geo-located data are displaced before being provided to researchers such that urban clusters are displaced up to 2 km and rural clusters up to 5 km (Burgert et al., 2013; Warren et al., 2016).

22.2.2 Calculating Travel Time

In addition to residential cluster locations, the study used GPS information for health facilities containing all government and non-government health facilities in Malawi, to calculate estimated travel-time(s) it takes, on average, for a woman to reach her nearest health facility for maternal health services. The assumed mode of transportation in the calculation of travel-time was walking and the radius was set to be 10 km based on the fact that it is a practical distance a person can travel for healthcare services (Blanford et al., 2012). Travel times to the nearest health facility were calculated in *QGIS* using Dijkstra algorithm, which is one of the classic shortest path search algorithms between nodes (Shu-Xi, 2012; Yan, 2014). The algorithm calculates the shortest path from an origin to a destination. Based on iterations over the set of vertices, at each iteration, the algorithm finds a vertex so that the distance from the origin vertex to the selected vertex is minimal (Rodríguez-Puente & Lazo-Cortés, 2013). However, instead of relaxing all adjacent nodes in each iteration, the algorithm filters out the nodes beyond the restricted area by checking if they are out of range (Dai, 2005). In this case, for every woman, the algorithm finds all the health facilities within her location and calculates the travelling distance to those facilities. When that is done, it then chooses the facility with the shortest travelling distance to be the nearest facility where the woman gets ANC services. Travel times were calculated at the speed of 5 km/h as it is more accurate measure of distance travelled. As such, we could not use Euclidean distance since it is rare for a person to travel in a straight line.

Figure 22.1 shows reproductive women's residential cluster locations and the location of health facilities, where the legend shows their respective travel times to the nearest health facility. For easy illustration, we extracted one sample district from the map.

Figure 22.2 is an extract of Lilongwe district. In the current study, 498 respondents were from Lilongwe. As seen in Fig. 22.2, Lilongwe urban has a lot of facilities in addition to having well-connected road networks. Such dense network of roads may result in reduced access time.

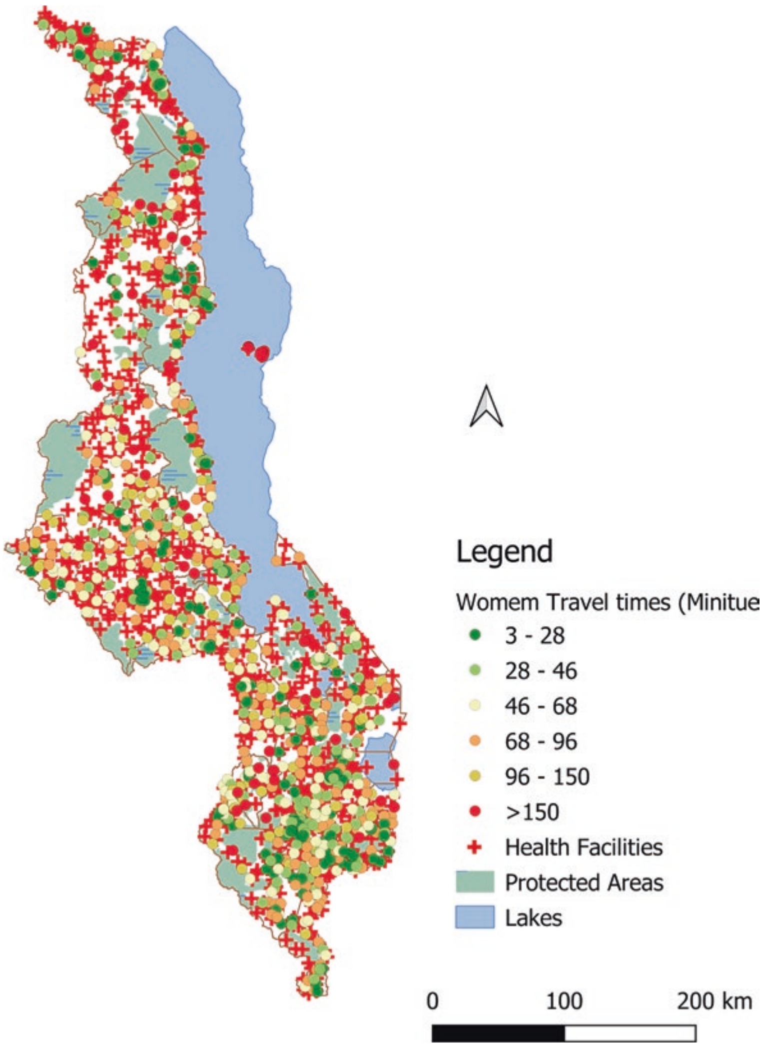

Fig. 22.1 Spatial access to the nearest health facility

22.3 Statistical Methods

A joint model was fit between access to the nearest facility (travel times) and the number of antenatal visit a woman would have (<4 visits or ≥4 visits) in order to capture dependence between them. Travel time has a Gaussian margin and antenatal visit category has a Bernoulli margin, giving rise to what is called a Generalised joint regression model (Masarotto & Varin, 2017). The two marginal models develop a bivariate model of mixed outcomes, which are specified as follows:

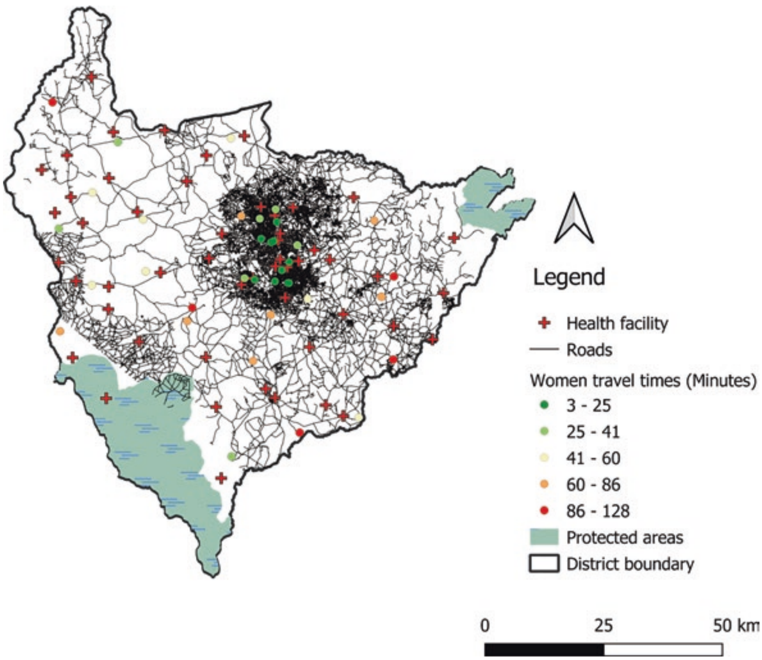

Fig. 22.2 An extract of Lilongwe district, showing location of health facilities and respective travel times

$$Y_{i1} \sim \text{Normal}\left(\mu_{i1}, \sigma^2\right) \text{with}\, \mu_{i1} = x_i \alpha \tag{22.1}$$

$$Y_{i2} \sim \text{Bern}\left(\pi_{i2}\right) \text{with logit}\left(\pi_{i2}\right) = z_i \beta + u_i + s_i \tag{22.2}$$

where Y_{i1} is the outcome for travel time, while Y_{i2} is the outcome whether four FANC were met or not. The covariates associated with each equation are x_i and z_i for the first and second outcomes, respectively, with α and β being corresponding regression parameters. Additionally, random effects were assumed to ANC marginal, where u_i and s_i capture unstructured and structured spatial effects, respectively.

The copula model used areal data to account for spatial dependence and spatial regression inference. Areas were considered to be neighbours if they share a common boundary making it necessary for joint analysis (Bivand et al., 2013). Variable district was fitted as both unstructured and structured random effect (geographical clustering) in the model. The unstructured term is analysed using a zero-mean constant variance process, $u_i \sim$ Normal $(0, \tau^2)$. On the other hand, a Gaussian Markov random field approach was applied to account for geographic clustering of antenatal care and assumes that district depends primarily on its neighbours. Let N_i be number of neighbours for a district s_i, then the neighbours are represented by s_j, $j \varepsilon N_i$ that are "close" to s_i. The spatial smoothing, through the Gaussian Markov random field process, is given by

$$p\left(s_i \middle| s_j \neq i\right) = N = \left(\frac{w_{ij}}{\sum_{j\varepsilon N_i} w_{ij}} s_i, \frac{\sigma^2}{\sum_{j\varepsilon N_i} w_{ij}} \varepsilon N_i\right) \tag{22.3}$$

where $w_{ij} = 1$ if i and j are neighbours and zero otherwise. Modelling spatial effects for the variable district were implemented using

```
s(district, bs="mrf", xt=xt, k=20)
```

where *mrf* stands for Markov random field. The neighbourhood structure information is stored in an object *xt* which is then used in specification of the Gaussian Markov random field smoother. To complete the model specification, the fixed effects, α and β, were analysed using diffuse prior distribution. A Student-*t* copula was used to measure the degree and direction of correlation between the two outcomes. Analysis was done in open source statistical environment **R** 3.6.1 (R Core Team, 2019), using *g jrm* function in the package GJRM-Generalised joint regression model.

22.4 Results

22.4.1 Description of Key Variables

Table 22.1 presents a summary of explanatory variables in the analysis and included age of a woman, region, place of residence, sex of household head, frequency of listening to radio, frequency of reading newspaper, if the woman is currently working, timing at first visit, household wealth status, number of antenatal care visits, education level, if a woman ever terminated pregnancy before and whether she wanted the pregnancy. The choice of the covariates was based on the studies by Machira (2017) and; Oladipo (2014) as they were shown to be significant determinants of maternal healthcare utilisation.

The two outcomes of interest were: (i) travel times (distance), which is a continuous outcome variable, and (ii) whether a woman has less than four visits or more than or equal to four visits – giving a binary variable. Out of the 9228 women, 47% of them had less than four visits and 53% had more than or equal to four visits. Of the total sampled women, 85% were from rural areas and 15% were from urban.

Table 22.1 Description of key variables

Variable	Description
Place of residence	0 = rural, 1 = urban
Antenatal care visits	0 = less than four visits 1 = more than or equal to four visits
Region	0 = north, 1 = central 2 = south
Sex of household head	0 = female, 1 = male
Level of education	0 = no education, 1 = primary education 2 = secondary education, 3 = tertiary education
Frequency of listening to radio	0 = none 1 = less than a week 2 = more than once a week
Working	0 = not working, 1 = working
Wealth index	0 = poor, 1 = poorer 2 = middle, 3 = richer, 4 = richest
Frequency of reading newspaper	0 = none 1 = less than a week 2 = more than once a week
Wanted pregnancy	0 = then, 1 = no more, 2 = later
Age of the mother	0 = 15–19, 1 = 20–24, 2 = 25–29, 3 = 30–34 4 = 35–39, 5 = 40–44, 6 = 45–49
Spatial effect	District: Administrative boundaries. Data were collected from 28 districts during the 2015/2016 MDHS.

22.4.2 Estimated Travel Time to Nearest Health Facility

Among the 9228 pregnant women, the average travel time was 56 min and the minimum travel time to the nearest health facility in both rural and urban areas was 3 min. Women from urban areas had median travel time of 22 min (e.g. in Lilongwe), while women from rural areas had median travel time of 66 min to the nearest health facility. The median travel time for women in the urban areas was less than those of women from rural. This shows that health facilities in the urban are usually close to people's residence unlike in the rural areas where women have to walk for a long distance to reach the health facility.

Women from the rural areas had to walk for as much as 149 min to get to the nearest facility. This indicates that with longer distance to the facility, the timing at the first visit is affected since one would consider the distance she needs to travel in the end affecting the number of visits one would have. In this study, out of 9288 women 832 of them had to travel more than 149 min to reach the nearest health facility. The median travel time to the nearest health facility for women from the Southern Region was 55 min, from the Northern Region was 61 min, whilst from Central Region was 62 min.

22.4.3 Bivariate Spatial Model Results of Access and Antenatal Care Visits

Table 22.2 presents estimates for the joint model of ANC visits and access to health facility. The smooth components approximate significance showed a p value of <0.001, which indicates that there was indeed spatial variation in utilisation of ANC across the districts. The estimated dependence parameter (θ) from Table 22.2 is −0.045, 95% CI (−0.064, −0.034). The small yet significant dependence measure obtained for the Student-*t* copula indicates that there exists negative association between access to the nearest health facility and achieving a focal number of antenatal visits. This suggests that women with less travel time to health facilities are more likely to have at least four ANC visits as recommended by the World Health Organization.

Results for the fixed effects from Table 22.2 shows that region, education, age, wealth index and whether the woman wanted pregnancy were all significantly associated with antenatal visit. Similarly, covariates that were seen to be significant with access to the nearest health facility were region, age of the woman and place of residence. Few variables were determinants of both outcomes. For example, region and age of the woman was seen to be significant in both models. Women from both Central and Southern region were less likely to access HF compared to those in the Northern region, and this translated into a reduced likelihood of achieving a minimum of four ANC visits in both regions compared to those in the Northern region.

Figure 22.3 below shows the district spatial variation of access to nearest health facility. Again in line with the *p*-value of the smooth function equations, with $p < 0.001$, there was significant spatial dependence at district level. With a scale of −6 to +6, geographical locations showed to have contributed to variations in access to health facilities across the country. Dedza, Mangochi and Ntcheu show a very strong spatial variation (with values: +4 to +6), followed by Machinga, Lilongwe, Dowa, Mchinji and Balaka (with values ranging from +1 to +3). This implies that most women in these districts were able to fully access the nearest health facility. On the other hand, those from districts such as Phalombe, Chitipa Karonga, Rumphi, Nkahatabay, Mulanje and Mzimba show the lowest spatial variation (with values from −6 to −3). Similarly, women from the following districts: Nkhotakota, Kasungu, Nsanje, Chikwawa, Zomba, Mwanza, Blantyre and Thyolo show, a moderate spatial variation (values from −2 to 0). Most women from districts in the northern region showed to have difficulties in accessing the nearest hearth facility as compared to women from central and some parts of the northern region.

Table 22.2 Spatial copula model estimates for ANC visits and access to health facility

	ANC visits			Access to health facility		
Parameter	Odds ratio	Std error	p-Value	Estimates	Std error	p-Value
Smooth component	<0.001					
Dependence parameter (θ)	−0.045	(−0.064, −0.034)				
Intercept	0.967	0.118	0.813	62.150	2.990	<0.001
Region: Ref. = *North*						
Central	0.602	0.095	0.001	−6.589	2.398	0.010
South	0.733	0.123	0.014	−6.190	3.084	0.044
Education: Ref. = *None*						
Primary	1.182	0.045	0.029	−1.041	1.143	0.363
Secondary	1.315	0.056	0.004	−1.988	1.430	0.163
Tertiary	2.591	0.122	<0.001	−0.187	2.839	0.947
Age: Ref. = *15–19*						
20–24	1.010	0.055	0.004	0.337	0.013	0.003
25–29	1.180	0.057	0.012	−0.278	0.013	0.042
30–34	1.273	0.060	0.017	1.449	0.014	0.005
35–39	1.267	0.062	0.037	0.308	0.015	0.018
40–44	1.143	0.077	0.005	1.763	0.017	0.007
45–49	1.804	0.111	0.001	−3.591	0.025	0.005
Working: Ref. = *No*						
Yes	1.143	0.056	0.154	−1.433	1.413	0.311
HH[a]: Ref. = *Male*						
Female	1.074	0.032	0.189	0.909	0.811	0.262
Wealth index: Ref. = *Poor*						
Poorer	1.024	0.042	0.737	0.419	1.067	0.695
Middle	1.092	0.0413	0.124	−0.279	1.099	0.799
Richer	1.030	0.046	0.960	1.088	1.165	0.350
Richest	1.360	0.058	<0.001	1.996	1.461	0.172
Residence: Ref. = *Rural*						
Urban	1.129	0.046	0.115	−3.324	1.163	0.004
Radio[b]: Ref. = *No*						
<a week	1.122	0.039	0.086	0.190	0.989	0.847
≥once a week	1.116	0.034	0.060	1.461	0.862	0.090
Newspaper[c]: Ref. = *No*						
<a week	1.010	0.046	0.923	−1.775	1.150	0.123
≥once a week	0.955	0.059	0.698	1.943	1.463	0.184
Evertempreg[d]: Ref. = *No*						
Yes	0.988	0.044	0.867	−1.619	1.113	0.146
Wantedpreg: Ref. = *Then*						
No more	0.745	0.045	<0.001	−0.533	1.145	0.641
Later	0.753	0.031	<0.001	0.522	0.782	0.504

[a]Household head sex
[b]Listening to the radio
[c]Reading news paper
[d]Ever terminated pregnancy

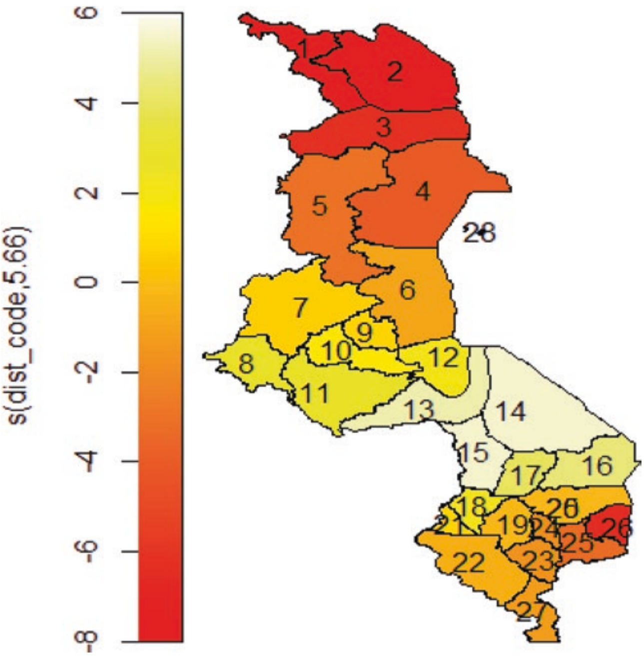

Fig. 22.3 Spatial variability of access to nearest health facility: Chitipa (1), Karonga (2), Rumphi (3), Nkhata Bay (4), Mzimba (5), Nkhotakota (6), Kasungu (7), Mchinji (8), Ntchisi (9), Dowa (10), Lilongwe (11), Salima (12), Dedza (13), Mangochi (14), Ntcheu (15), Machinga (16), Balaka (17), Neno (18) Blantyre (19), Zomba (20), Mwanza (21), Chikwawa (22), Thyolo (23), Chiradzulu (24), Mulanje (25), Phalombe (26), Nsanje (27), Likoma (28)

22.5 Discussion

This study has examined the joint dependence of access to health facility and meeting a focal number of ANC visits. The results from a joint modelling showed varied determinants with a number of explanatory variables associated with ANC visits, and only three variables (region, age and place of residence) associated with access to HF. In both models, only region and age of the woman were significant. This clearly demonstrates that access is strongly associated with geographical location (Fig. 22.3), thus access is strongly driven by geographical differences in the regions. For instance, in the north, they are a lot of protected areas like mountains, rivers and lakes, which could somehow hinder the women to go for antenatal services due to difficulties in walking. On the other hand, the central region of Malawi is a bit flat compared to the northern part as such women from the central region districts were able to access the care thereby having the required number of antenatal care visits.

Furthermore, the spatial variation in Fig. 22.3 could be a factor of density of health facilities in the district, with those having a high density would likely have easy access to the health facility. Similarly, rurality has often been used as a proxy for inaccessibility. The more rural districts such as Mzimba in the north, Phalombe in the south are likely have less access to HF. These results are similar to the study done by Edward (2011) which looked at factors influencing the utilisation of antenatal care in Uganda. The study showed that location differences were significant in influencing the utilisation of antenatal care content. Being in the rural area, compared to one in the urban area, reduced the utilisation of antenatal care by 0.3 ($p < 0.01$) to 0.4 ($p < 0.01$) percentage points. This is so possibly because the health facilities in the rural areas are very far from women's residence; hence, one would choose to initiate the antenatal visit late in the end having low number of visits.

In addition to that, most rural areas do not have well-connected roads making it difficult for the women to reach the facilities. This was evident in this study. The median travel distance for women in the rural areas was also seen to be a bit high than the median in the urban areas, which simply tells us that women in the rural areas had to travel longer distances to reach their nearest health facility. The results in this study also agree with the MDHS report that women in rural areas were more likely to report at least one problem accessing health care than women in urban areas (76% and 56%, respectively) (National Statistical Office-NSO/Malawi and ICF, 2017).

The results on access to the nearest health facility are also similar to what Gupta et al. (2014) found in a study where he was looking at factors associated with four or more antenatal care visit and its decline in Tanzania. They found that many women had to travel a long distance to the nearest facility hence reporting less ANC visits. Ali et al. (2018) also revealed a very strong association between distance and attendance of ANC. In most cases, distance has been identified as an important barrier to the use of health services, especially in rural areas (Noorali et al., 1999; Palk et al., 2020; Johansson et al., 2020). A study from Pakistan found out that access to obstetric care depends upon the transportation system and physical distance between the villages and the centres (Midhet et al., 1998). Kambala et al. (2011) also identified long distances to access health centres as one factor that hinders pregnant women to use antenatal clinics (ANC), delivery and postnatal care in Chikhwawa district in Malawi.

22.6 Conclusion

Access to the nearest health facility and antenatal care visit are negatively associated, as somehow expected, which simply suggest that those women who had more than four visits may have no difficulties in reaching the nearest health facilities, probably they could have less travel time. Considering that the estimated distance to the nearest health facility for rural women is much longer, deliberate efforts should be targeted towards such areas. For example, the government may introduce mobile ANC clinics (branded *a clinic in your neighbourhood*), to reduce stress walking to a health facility, which in return should motivate utilising ANC services more regularly. Of course it is also evident that other factors also play a part. For example, service availability and readiness to offer services are critical. If services are available and there is an adequate supply of services, then the opportunity to obtain health care exists, and a population may "have access" to services.

Much as this study has made the above findings, it is safer to say that the findings of the study cannot be conclusive because most variables in the 2015/2016 MDHS data had a lot of missing values, thus causing the results to be bias. Despite this limitation, the study has, however, provided a baseline data for policy makers and researchers in carrying out further research and implementing policies that could help to improve access to healthcare service.

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Chapter 23
Territorial Study of the Distribution of Doctors in Gabon

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23.1 Introduction

The shortage of human resources in the healthcare sector is a phenomenon that affects the performance of healthcare systems. This situation impacts on the availability of and access to quality healthcare for the population, particularly those in rural areas. According to the World Health Organization (WHO), there is a shortage of four million healthcare workers worldwide, including more than one million in Africa (Dhaene, 2011). There are many reasons for this shortage. These include shortcomings in the management of careers and training, the low attractivity of remuneration and the working environment as well as professional and family prospects geared towards emigration and the attractivity of economically more advanced countries with significant needs in healthcare workers. These are all factors that aggravate the underperformance of healthcare systems in sub-Saharan Africa (*idem*).

In many countries in the South, healthcare policies are based on the notion of equity, a basic principle of spatial justice (Ridde, 2012). Equity of access to care is at the heart of public policy in terms of resource allocation, a prerequisite for social and territorial justice (Picheral, 1992). In Gabon, this allocation leaves significant territorial fractures. The supply of healthcare personnel is characterised by disparities between healthcare regions, thus hindering territorial justice.

Instead of reflecting on the demand for healthcare care, there is often a tendency to act on the supply to ensure equal access to healthcare for all. An equitable

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distribution of healthcare resources would thus be the first condition for spatial justice in healthcare. Hence the need to measure and evaluate spatial disparities in healthcare provision in order to be able to eliminate them. It is on this basis that the present reflection on the territorial distribution of doctors in Gabon, as a statistical study of the medical population, was conceived.

The aim is to analyse the spatial disparities in healthcare care, their determinants and the quality of healthcare through the analysis of some healthcare indicators. During this study, we will refine our analysis by evaluating the distribution of doctors at national level in the light of the standards laid down by the WHO.

23.2 Organisation of the Gabonese Healthcare System

The Gabonese healthcare system is based on three sectors: a public sector, a private sector and a parapublic sector. The first one is made up of the civilian and military public sectors. The second one distinguishes between the private for-profit and private non-profit sectors. Finally, the third sector concerns the parapublic sector. The latter does not depend directly on the Ministry of Health but on the National Social Security Fund (CNSS) which is the parastatal body responsible for managing part of the public service.

The civil public sector, which is the subject of our study, has a pyramidal organisation in three levels (peripheral, intermediate and central) modelled on the general administration. According to Decree 0142/PR/MSPS of 2 March 2015, on the reorganisation of healthcare regions and departments, Gabon has 10 healthcare regions and 51 departments. But this regulatory provision is not being applied yet. The old division remains, with 10 regions and 50 healthcare departments. To date, the number of healthcare departments is 51, based on the administrative division.

The central level includes all the central directorates, including the national programmes in Libreville, the institutes, the reference healthcare and diagnostic structures, notably four university hospital centres (CHU) and the national pharmaceutical office. The secondary or intermediate level is made up of ten regional healthcare directorates and nine hospitals or regional hospital centres (CHR) located in each provincial capital. These establishments serve as a reference for the structures of the first level of the healthcare pyramid.

The primary or peripheral level is composed of 43 medical centres/departmental hospitals, 35 healthcare centres, 444 dispensaries and 21 healthcare huts. This level is that of the healthcare department. The medical centre or departmental hospital, located in the administrative departmental capital, serves as a reference for this level.

The public military sector is directly affiliated to the Ministry of Defence. It consists of a large modern hospital with a high-performance technical platform, the Omar Bongo Ondimba Army Training Hospital (HIAOBO) in Libreville; military healthcare centres, a network of infirmaries and training institutions; and the Military healthcare Service Training School in Libreville (ESSSML). In addition, the military healthcare service can deploy field hospitals. There are also eight (8) prison infirmaries staffed by the Ministry of Justice.

The parapublic sector (CNSS) has six medical and social centres throughout the country, in addition to the mobile emergency and resuscitation service (SMUR) in Libreville. The private non-profit sector is represented by the International Centre of Medical Research of Franceville (CIRMF), the Centre of Medical Research of Lambaréné (CERMEL), the COMILOG hospital in Moanda in Haut-Ogooué, the Albert Schweitzer hospital in Lambaréné and the Evangelical hospital in Bongolo in Ngounié. This sector includes clinics run by non-governmental organisations and religious denominations. The private for-profit sector includes polyclinics and clinics, medical practices, medical analysis laboratories, pharmaceutical wholesalers, pharmaceutical dispensaries, pharmaceutical warehouses and a rehabilitation and equipment centre. In addition to the various sectors described above, there is a traditional medicine that is being organised. The breakdown of the Gabonese healthcare system into its 10 healthcare regions is summarised in a map (Fig. 23.1). The Gabonese healthcare system relies on healthcare facilities to provide care. Figure 23.2 shows some of the healthcare facilities serving the Gabonese population.

23.3 Data and Method

The statistical data used in this work comes from different sources. The demographic data comes from the 2013 General Census of Population and Housing. These data were projected to 2017 by the Expanded Programme of Vaccination. It is based on these data that the levels of medical services, maternal mortality rate and the number of women at childbearing age have been calculated. Data on doctors were taken from the Ministry of Health reports, the statistical yearbook, the healthcare map and general scorecard of 2017 and the healthcare sector standards of 2012. The population data and the child mortality (under 5 years) are taken from the Expanded Programme on Immunisation (EPI) projection for 2019. However, the data on child mortality due to malaria are taken from the National Malaria Control Program of 2019. The number of doctors in 2019 is taken from the Central Human Resources Department.

The study covers doctors in the civilian public sector; all categories are combined. This choice may give rise to fears that the data will be partial, insofar as it does not consider the private sector. However, this observation must be put into perspective. The liberalisation of the healthcare sector in Gabon in the 1990s following the national conference effectively allowed the emergence of a private healthcare sector. However, the private healthcare sector remains the prerogative of large urban centres such as Libreville and Port-Gentil. Not considering data from the private sector, even if the workforce in this sector were completely detached from the public sector, would therefore underestimate the level of service in areas already advantaged by public sector resources. In fact, many public sector doctors also practise in the private sector when they are not the main promoters (Makinen et al., 2012) cited by E. Paka (2018, p. 127).

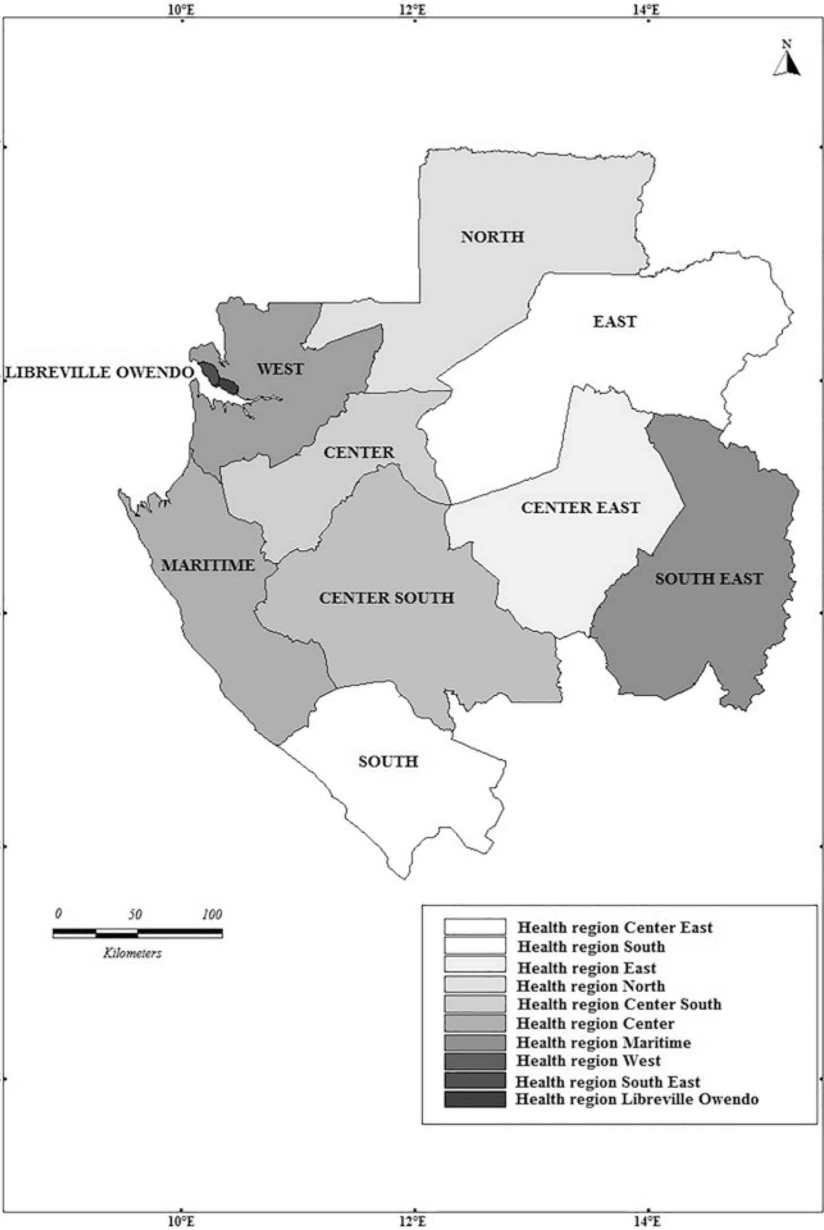

Fig. 23.1 Healthcare regions in the Gabonese Republic. (Source: Ministry of Health, Statistical Yearbook 2017 – cartographic support: INC – design: E. Makita – production: B.A Elemy)

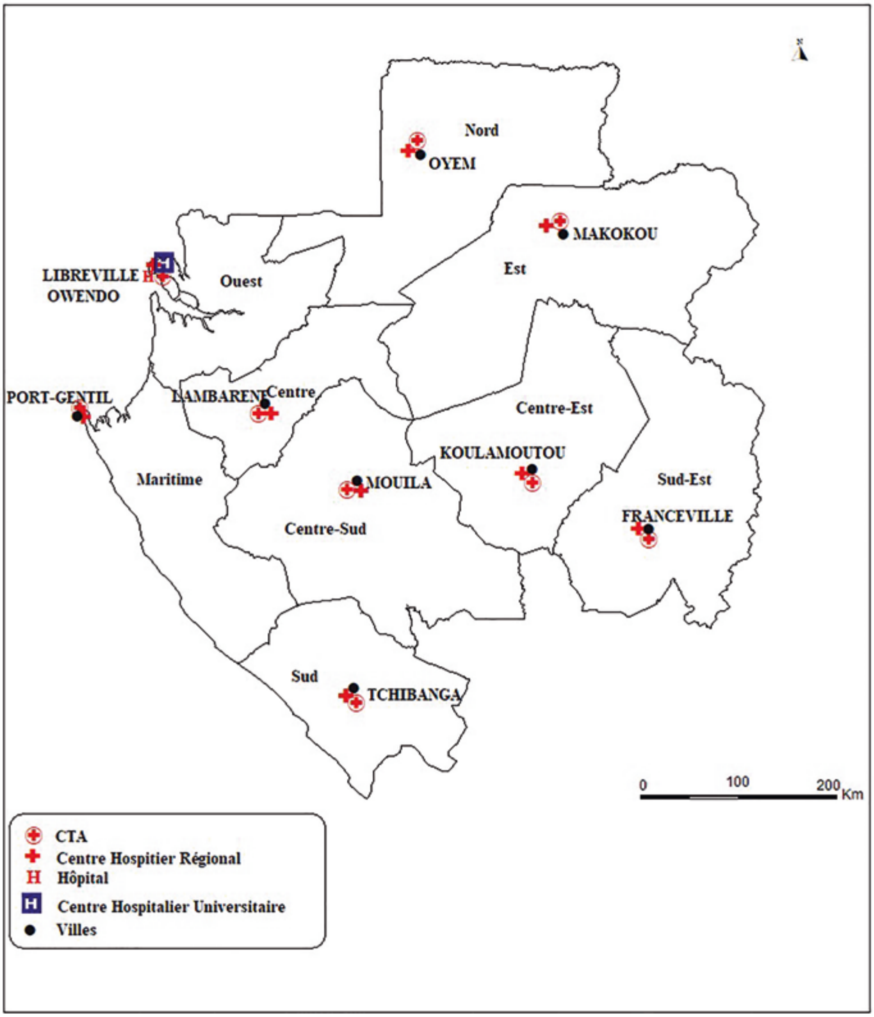

Fig. 23.2 Healthcare facilities in the Gabonese Republic. (Source: Ministry of Health, Statistical Yearbook 2017 – cartographic support: INC – design: E. Makita – production: B.A Elemy)

Medical service was studied at the level of the healthcare region. We should have studied it at the level of the department, and we are aware of the limits of this choice in terms of healthcare planning. The indicator used was medical density (number of doctors for a population). This medical density was compared to WHO standards and to the national healthcare standards of 2012 to refine the analyses. The reference year for calculating medical density was 2017, the year in which the Expanded Programme of Vaccination carried out its population projections, and this date coincides with the publication of the statistical healthcare yearbook, healthcare map and scorecard. The maps were made with Map Info and the tables and graphs with Excel.

23.4 Results

The results of this work first present the question of the distribution of doctors according to healthcare regions and then the link between this distribution and spatial planning and, finally, the quality of healthcare in relation to the distribution of doctors in Gabon.

23.4.1 Concentration of Doctors in the Healthcare Region Libreville/Owendo

More than half of the doctors in Gabon work in the urban area of Libreville, where most of the Gabonese population resides. Considering WHO standards and the analysis of the doctor to population ratio, it can be concluded that all healthcare regions in Gabon have an above-average doctor to population ratio as required by WHO (Table 23.1). This distribution of doctors by healthcare region does not conform to national norms which are based on the needs for medical personnel by type of healthcare structure (Table 23.3).

Table 23.1 Distribution of population and doctors by healthcare region in 2017

Healthcare region	Estimated population in 2017 (EPI)	% of the population	Doctors	% of doctors	Doctor to population ratio
Libreville/Owendo	879,891	43.6	585	70.1	1 doctor/1504 people
West	116,546	5.8	43	5.2	1 doctor/2710 people
South-East	297,646	14.7	64	7.7	1 doctor/4650 people
Centre	75,440	3.7	24	2.9	1 doctor/3143 people
South-Centre	114,240	5.7	24	2.9	1 doctor/4760 people
South	50,420	2.5	14	1.7	1 doctor/3601 people
East	71,669	3.5	15	1.8	1 doctor/4777 people
East-Centre	74,094	3.7	11	1.3	1 doctor/6735 people
Coast	162,967	8.1	31	3.7	1 doctor/5257 people
North	177,179	8.8	23	2.8	1 doctor/7703 people
Total	*2,020,092*	*100.0*	*834*	*100.0*	

Source: Ministry of Health, Statistical Yearbook 2017 – design: E. Makita-Ikouaya, 2019

In the same vein, the WHO standards for the allocation of doctors in a territory allow for the calculation of gaps between the number of doctors recorded in the field and the number of doctors recommended by the WHO. As shown in Table 23.2, Libreville has the largest gross surplus of doctors with 497 doctors in 2017. This is well above the WHO standard of one doctor per 10,000 inhabitants.

Continuing the analysis of medical demographics in Gabon and referring to Gabonese healthcare sector norms for human resource allocations, Table 23.3 shows a clear difference between the forecasts resulting from the application of WHO standards and those from national norms. According to WHO standards, Gabon has 202 doctors (Table 23.2) whereas Gabonese standards estimate at least 327 doctors in the healthcare services without considering those who will have to work in the administrative structures of the Ministry of Health (Table 23.3). This hypothesis considers the fact that each university hospital could have twice as many doctors in the regional hospitals (15 doctors × 2).

23.4.2 Spatial Planning and Distribution of Doctors

The imbalance observed between the Libreville/Owendo healthcare region and the rest of the country translates into an imbalance between the Libreville/Owendo healthcare region and the rest of the country. The analysis of the distribution of doctors in Gabon, considering WHO standards and national standards in relation to spatial planning, inspires the following.

It can be seen from Table 23.2 that, considering WHO standards on the distribution of doctors in relation to the population (1 doctor per 10,000 inhabitants), all the

Table 23.2 Differences between the number of doctors counted in the field in 2017 and the expected number of doctors

Healthcare region	Estimated population in 2017	Number of counted doctors	Theoretical number of doctors according to WHO standards	Surplus of doctors
Libreville/ Owendo	879,891	585	88	+497
West	116,546	43	12	+31
Southeast	297,646	64	30	+34
Centre	75,440	24	8	+16
South-Centre	114,240	24	12	+12
South	50,420	14	5	+9
East	71,669	15	7	+8
East-Centre	74,094	11	7	+4
Coast	162,967	31	16	+15
North	177,179	23	17	+6
Total	*2,020,092*	*834*	*202*	*+632*

Source: Ministry of Health, Statistical Yearbook 2017 – design: E. Makita-Ikouaya, 2019

Table 23.3 Distribution of doctors according to national standards

	Structures																					
	CHU		Hôpital		CNTS		CRTS		LNSP		IH		CTA		CDT		CHR		CM		CS	
RS	Nb S.[a]	NMR[b]	Nb S.	NMR	Nb S.	NMR	Nb S.	NMR	Nb S.	NMR	Nb S.	NMR	Nb S.	NMR	Nb S.	NMR	Nb S.	NMR	Nb S.	NMR	Nb S.	NMR
L/O	3	30	3	10	1	5	0	0	1	5	0	0	1	2	1	0	0	0	1	2	10	1
West	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	1	15	4	2	1	1
South-East	0	0	1	10	0	0	0	0	0	0	0	0	1	2	1	0	1	15	10	2	1	1
Centre	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	1	15	1	2	2	1
South-Centre	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	1	15	8	2	4	1
South	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	1	15	5	2	4	1
East	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	1	15	3	2	2	1
East-Centre	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	1	15	3	2	4	1
Coast	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	1	15	2	2	1	1
North	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	1	15	4	2	6	1
Total	*3*	*30*	*4*	*20*	*1*	*5*	*0*	*0*	*1*	*5*	*1*	*0*	*10*	*20*	*17*	*0*	*9*	*135*	*41*	*82*	*35*	*35*

Source: Healthcare sector standards, Ministry of Health 2012

CNTS National Centre for Blood Transfusion, *CRTS* Regional Centre for Blood Transfusion, *LNSP* National Public Healthcare Laboratory, *IH* Institute of Hygiene, *CTA* Outpatient Treatment Centre, *CDT* Treatment Centre, *CHR* Regional Hospital Centre, *CM* Medical Centre, *CS* Healthcare Centre

[a]Number of facilities counted in the healthcare region (NbS)

[b]Number of doctors recommended according to the national standard developed by the Ministry of Health in 2012 (NMR)

healthcare regions of Gabon have a ratio well above the standards recommended by WHO. The differences between the number of doctors counted in the field and the WHO recommendations are significant. The Libreville/Owendo healthcare region has the largest surplus of doctors (Table 23.2) and at the same time the best doctor/population ratio. This reflects a high concentration of doctors in this region, far from the 88 doctors recommended by the WHO standard established according to demographic weight (Tables 23.1 and 23.2), thus testifying to regional disparities in the distribution of medical staff.

In Gabon, the distribution of doctors, considering the population variable as proposed by the WHO, is subject to numerous biases. Among these are the difficulties of geographical access to healthcare facilities due to the poor state of communication in certain areas of the country. Engo Assoumou (2013) distinguishes three levels of accessibility in Gabon. There are sectors that have good accessibility because their network is very well meshed with access provided to each concession. Then, there are sectors with average accessibility and a low level of equipment because the streets are largely distant from each other. Finally, there are sectors that are difficult to access, corresponding to rural areas and under-integrated zones on the scale of the country; their inaccessibility is due to steep slopes, irregular densities according to their situation and configuration in the territorial network and the inexistence of motorable roads.

We believe that the approach aimed at allocating doctors based on the typology of healthcare facilities proposed by the Ministry of Health seems to be the best adapted to the realities encountered in the field. Indeed, the Ministry's norm aims to allocate human resources according to the minimum package of activities of each healthcare facility. The minimum package of activities refers to the services each type of healthcare facility is able to provide.

The fact that the particularity of the Gabonese terrain wasn't taken into account seems to justify the discrepancy noted between the recommendations formulated by the WHO in terms of the distribution of doctors and the norms of the healthcare sector in force in the Gabonese Republic. It is this particularity that shows that the norm defined by the Gabonese Ministry of Health is the system for distributing doctors that is best adapted to national contingencies, beyond the demographic importance of the healthcare regions that underlie the WHO norms.

In any case, whether it is a question of the WHO norm or the norms of the healthcare sector in terms of allocation of human resources in Gabon, the Libreville/Owendo healthcare region has the bulk of the doctors in addition to its significant demographic weight (43.6% of the Gabonese population, see Table 23.1). The imbalance observed between the Libreville/Owendo healthcare region and the other healthcare regions in terms of medical demography is explained by various factors. These include the level of urbanisation of the healthcare regions; the distance of the regions from the country's political capital, Libreville; their demographic weight; and the importance of an economic fabric at regional level. In this respect, Libreville, in view of its political and administrative history, has most of the socio-administrative infrastructures. If we also consider its demographic weight on a national scale, it is easy to understand the installation of doctors in its favour and despite the balance in the distribution of doctors throughout the territory.

In addition, other less populated healthcare regions sometimes have more doctors than the more populated healthcare regions (Table 23.1). Overall, the distribution of doctors in Gabon according to healthcare regions shows inequalities between them with a concentration of doctors in the Libreville/Owendo healthcare region.

The issue of the concentration of doctors in the major urban centres is not specific to Gabon. The same phenomenon can be observed in other countries such as Congo-Brazzaville where some departments have 1–2 doctors per 100,000 inhabitants. Maud Harang (2007) reports that Ouagadougou (Burkina Faso) has 47% of doctors compared to only 10% of the population. In Côte d'Ivoire, a study by the BNETD (2013) indicates that almost 47% of the country's doctors work in Abidjan, while about 20% of the national population lives there.

The private sector in France is also experiencing the same phenomenon of concentration of doctors in the major urban centres. As Sandier et al. (2004) have shown, Paris and the other regional urban centres in France contain the bulk of the doctors. Picheral (1992) explains this phenomenon by the fact that "the practitioner chooses to practice where he thinks he will find the optimal conditions for professional success. In other words, where there is a potential, large and solvent clientele, but also good working conditions. This differentiation in the value of space is at the expense of the least attractive places and population" (individual translation). Even if the sectors to which doctors belong are different (private and public), their reasons for setting up are almost similar, since most Gabonese doctors in the public sector prefer to set up in the big cities, particularly in Libreville, where they can also practise their profession in the private sector.

The problem of the concentration of doctors in African capitals cannot be explained solely by their demographic weight. They are also places of power where major political and administrative decisions are taken, in addition to the high-performance and modern technical facilities found in certain hospitals. Technological innovations in medicine can also be considered as a factor favouring the installation of doctors in African capitals.

Another phenomenon observed in African capitals is the practice of private medicine. This attracts many doctors from the public sector for various reasons such as increasing their income and benefiting from better working conditions.

In short, the geography of doctors in Gabon seems to be strongly linked to the planning of the territory. Thus, the large urban centres concentrate most doctors to the detriment of the country's healthcare balance and the medical care of territories located in rural areas. The spatial distribution of doctors is indicative of a territorial framework strongly marked by macrocephaly and disparities in the distribution of practitioners between the provinces. As a result, Libreville appears to be a factor of spatial inequality in the distribution of doctors at the national level. But more than its size, it is the functions of the city that determine the logic of accumulation and therefore of spatial concentration of resources.

To borrow from the words of Etienne Paka (2018), the functions of the city and the representations of which it is the object seem to depend on the location of doctors and therefore on the spatial inequalities of medical services. The hospitals in Libreville attract doctors and at the same time guarantee their influence. Thus, the geography of doctors contributes to territorial construction by making Libreville the attractive centre. What is true for doctors is also true for all public and private healthcare resources. The link between spatial planning and the distribution of resources is very clear (Salem, 1998; Vaillant, 2009; Amat-Roze, 2011; Echard-Bezault, 2011). As Salem et al. write (2016, p. 55), "a broad conception of spatial planning, including public healthcare issues, could be an important lever for economic development and not only for growth" (individual translation).

23.4.3 Quality of Care and Distribution of Doctors in Gabon

The question of evaluating the quality of care is a difficult but not impossible subject in public healthcare. American authors have led the way in this field, whereas the tendency in Europe is to claim that medical care should be free from evaluation. The doctor is supposed to provide better quality care (Paret, 1984, p. 178). According to the WHO, quality of care is "an approach which should ensure that each patient is provided with the range of diagnostic and therapeutic procedures which provide the best healthcare outcome, in accordance with the current state of medical science, at the lowest cost for the same result, with the least iatrogenic risk, and with the greatest satisfaction, in terms of procedures, outcomes and human contacts within the healthcare care system" (individual translation). For Donnabedian (1978), the concept of quality of care covers three dimensions: structures, procedures and outcomes. Structures refer to the different means used in the provision of care. The term "procedure" encompasses the different activities of the care providers (doctors or nurses in their relationship with the patients). Outcomes are the estimation of the final effects of a care procedure on the health of patients. Talking about the quality of care and the distribution of doctors means choosing some healthcare indicators that can be used to judge the quality of care. In this study, we chose the number of maternity deaths and malaria deaths among children under 5 years by healthcare region as healthcare indicators that could assess the quality of care. The choice of these indicators is not accidental. There are two reasons. The first reason is that the issue of maternity healthcare has become a global concern, with 57% of all maternity deaths occurring on the African continent. This makes Africa the region with the highest maternity mortality ratio in the world (UNFPA, 2013). The second reason is related to the unavailability of data. The problem of data availability in Africa is well known. For this study, we were unable to obtain data on maternal and under-five malaria deaths that would allow us to judge the quality of care between healthcare regions in Gabon. Table 23.4 on the distribution of maternity deaths by healthcare region in Gabon in 2017 is presented as follows.

Table 23.4 shows that the Libreville/Owendo healthcare region has a better indicator in terms of maternity deaths related to women in childbearing age (1 death for 2157 women in childbearing age), whereas this indicator is higher in other

Table 23.4 Distribution of maternity deaths by healthcare region in Gabon in 2017

Healthcare region	Number of maternity deaths	Population in childbearing age	Maternal death indicators/ women of childbearing age	Number of doctors
Libreville/ Owendo	93	200,615	1 death for 2157 women in childbearing age	585
West	1	26,430	1 death for 26,430 women in childbearing age	43
Southeast	1	67,863	1 death for 67,863 women in childbearing age	64
Centre	0	17,200	0 death for 17,200 women in childbearing age	24
South-Centre	4	26,047	1 death for 6511 women in childbearing age	24
South	14	12,723	1 death for 908 women in childbearing age	14
East	1	16,340	1 death for 16,340 women in childbearing age	15
East-Centre	0	16,893	0 death for 16,893 women in childbearing age	11
Coast	1	37,156	1 death for 37,156 women in childbearing age	31
North	0	40,397	0 death for 40,397 women in childbearing age	23
Total	*114*	*616,666*		*834*

Data source: Statistical Yearbook 2017 – design E. Makita-Ikouaya, 2019

healthcare regions. From this indicator, maternity healthcare seems to be of better quality in the Libreville/Owendo Healthcare region where there are a higher number of doctors compared to other healthcare regions. However, it is difficult to make an immediate link between the high presence of doctors and the number of maternity deaths, given the multitude of factors that may be related to maternity deaths (lack of medicines, geographical accessibility to healthcare facilities) in addition to the quality of the data. With regard to the latter aspect, the lack of data quality may justify the fact that in 2017, the Centre East and North healthcare regions did not experience any maternal deaths.

The observation that the healthcare no longer meets the expectations of the population was already made in 1998 when the National healthcare Action Plan was drawn up, in which healthcare professionals recognised their limitations in providing quality care to the Gabonese population, which is prey to several endemic diseases.

23.5 Discussion

The spatial distribution of doctors in the civilian public sector reveals a territorial imbalance between the healthcare regions where Libreville/Owendo has the bulk of medical resources. The city of Libreville, because of its very strong attraction, appears to be a factor of spatial inequality in the distribution of healthcare resources on a national scale. But more than its size, it is the administrative and political functions of the city of Libreville that determine the logic of accumulation and concentration of resources. These functions are complementary and mutually reinforcing (Morin, 2005). The hospitals in Libreville attract doctors even more because they are located in the capital city, whose functions guarantee an influence that accentuates the phenomenon of polarisation of the capital. The unequal distribution of doctors and the spatial disparities observed in terms of medical services between the capital and the rest of the country are indicators of a polarised and hyper-centralised national territory. This work clearly raises the question of the link between spatial planning and the distribution of healthcare resources. As Gérard Salem (1998) wrote, "a broader conception of spatial planning, including public Healthcare issues, could be an important lever for economic development and not only for growth" (individual translation). Paka (2018, p. 126) already stressed that public policies on the allocation of healthcare resources must necessarily include a territorial dimension in order to achieve the objective of spatial justice which is the basis they rely on. In terms of quality of care, it is not certain that the population of the Libreville/Owendo healthcare region, where most of the medical resources are concentrated, has better healthcare than the populations of the country's other healthcare regions, given that the public authorities had already noted a questionable quality of care in 1998 through the National Healthcare Action Plan. Thus, the quality of care and the concentration of doctors in the healthcare region of Libreville-Owendo do not guarantee better care for population suffering from several endemic diseases.

23.6 Conclusion

The distribution of doctors in Gabon reveals a concentration of doctors in the healthcare region of Libreville/Owendo. This healthcare region, to which Libreville, the capital of the Gabonese Republic, belongs, represents a place of power and reveals the primacy of political and territorial factors, more than that of needs, in the spatial distribution of human resources. This study therefore reveals inequalities in the distribution of doctors across the different healthcare regions of Gabon, even if it did not make an operational distinction between doctors working in the administration and those working in healthcare care structures.

The inequalities observed have a negative impact on patient care and satisfaction. Healthcare is part of the United Nations Sustainable Development Goals (SDGs), particularly the third goal about healthcare, which aims, among other things, to ensure the health and well-being of all people at all ages. However, this goal cannot be achieved if medical personnel is not available in certain territories. For this reason, one of the milestones to achieve this goal is the recruitment, development and retention of healthcare personnel in developing countries. At the state level, particularly in Africa, the fair distribution of medical personnel throughout the country appears to be a development imperative. Gabon must adopt a policy for the management of its healthcare human resources that aims to meet this objective of sustainable development.

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