UNIVERSITY OF CAPE COAST

CHILD NUTRITIONAL OUTCOMES: ISSUES OF SPATIAL CLUSTERING AND NEIGHBOURHOOD EFFECTS IN SUB-SAHARAN AFRICA

VIDA AFAREBEA AGYEN

2020

UNIVERSITY OF CAPE COAST

CHILD NUTRITIONAL OUTCOMES: ISSUES OF SPATIAL CLUSTERING AND NEIGHBOURHOOD EFFECTS IN SUB-SAHARAN AFRICA

BY

VIDA AFAREBEA AGYEN

Thesis submitted to the Department of Economic Studies of the School of Economics, College of Humanities and Legal Studies, University of Cape Coast, in Partial Fulfilment of the Requirements for the Award of Doctor of Philosophy Degree in Economics

OCTOBER 2020

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature ………………………… Date …………………………

Name: Vida Afarebea Agyen

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature: ………………..……… Date …………………

Name: Prof. Samuel Kobina Annim

Co-Supervisor's Signature: ……………..………….. Date ……………..…

Name: Dr. Emmanuel Ekow Asmah

ABSTRACT

This thesis addresses three objectives: (1) assess spatial dependence of stunting in children (2) examine the effects of neighbouring mothers' education on child health, and (3) investigate differences in the neighbourhood effects of the correlates of stunting. Data from the last round of the Demographic and Health Surveys of Ghana and 29 other Sub-Saharan African countries are used. The Moran's I statistic and the Local Indicator of Spatial Association statistic are computed to assess the extent of spatial dependence of stunting rates. Spatial Lag and Spatial Error models are used to ascertain the cause of spatial dependence and the effect of neighbourhood mothers' education on stunting. Structural Equation Modelling is used to ascertain the effect of socioeconomically advantaged neighbourhoods on stunting and wasting in Ghana. Multilevel logistic regressions are employed to examine the neighbourhood effects of the correlates of stunting. The results of the spatial analysis show that 17 districts with high rates of stunting are clustered in the north-eastern part of Ghana. The study found that the effect of stunting in adjacent neighbourhood districts is 19 per cent as large as it is in the focal district in Ghana. The Structural Equation Model shows that children living in advantaged neighbourhoods have better health outcomes. Achieving a target of at least 75 per cent of mothers obtaining secondary education and higher could bridge the rural-urban gap in stunting in Sub-Saharan Africa. Improved water reduces a child's probability of being stunted by 1 per cent in a rural area and 4 per cent in urban. Initiatives to address stunting should be broadened to cover districts with the likelihood of contributing to poor child health outcomes in adjoining settlements.

KEYWORDS

Child Health Disparities

Externalities

Improved Water Sources

Neighbourhood effects

Neighbourhood Mothers' Education

Social Capital

Spatial Dependence

ACKNOWLEDGEMENTS

I am grateful for this journey and for the following individuals who came my way.

Special appreciation goes to my principal supervisor, Professor Samuel Kobina Annim, for his expertise and mentorship. Prof, Thank you for believing in me even when I did not know how. I have been so lucky to have you as a supervisor. For your patience, understanding and support, I am profoundly grateful. I am equally grateful to Dr Emmanuel Ekow Asmah for his invaluable support and time. I would also like to thank Prof. Kofi Awusabo Asare, whose ideas and resource materials helped in keeping this study in perspective, and to the staff of the School of Economics for their constructive criticisms and advice.

I could never have words to appreciate my husband, Edward Amaning Aboagye and children, Nana Kwame, Nala Ama Bema and Papa Kofi Ayeh. You are the best I could ever ask for. I thank my parents, Edward Agyen and Emelia Agyen for the love and sacrifices. I am forever grateful.

For listening to my thoughts and frustrations, I thank my closest friend Dr Lydia S. Asante. Also for listening and urging me on, I am grateful to Dr Raymond Kofinti, Dr. Prince Frimpong Manso, Bismark Anokye, Dr. Isaac Koomson, Derrick Ofori Donkor, Dorothy Aboagye-Mensah, Madam Bernice Obeng, Dora Duah Bisiw, Akwasi Akomea Agyekum, Nana Kwame Akowuah, Kwabena Nyarko Addai, Rev. Adu Okoree, Mr and Mrs Opoku Amoako, Cletus Ogenete, Roger Aniah, Miracle Morrison, Nathaniel Mensah and Samuel Amoako. Thank you to Mrs Mary Afedzi and Cecilia Ninson who looked after my infants so that I could attend seminars and study.

DEDICATION

To the Agyens and Amaning Aboagyes.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure **Page**

LIST OF ACRONYMS

BMI	Body Mass Index
CSDH	Commission of Social Determinants of Health
CSO	Civil Society Organisations
DHS	Demographic and Health Surveys
EmONc	Emergency Obstetric and Newborn Care
ESDA	Exploratory Spatial Data Analysis
GDHS	Ghana Demographic and Health Survey
GHS	Ghana Health Service
GLSS	Ghana Living Standard Survey
GNPRI	Global Nutrition Policy Review
GSS	Ghana Statistical Service
HAZ	Height for Age Z-score
ICN2	Second International Conference on Nutrition
LISA	Local Indicator of Spatial Association
LMIC	Low-and middle-income countries
MDA	Ministries, Departments and Agencies
MDG	Millennium Development Goal
NLiS	Nutritional Landscape Information System
NNP	National Nutrition Policy
NPAN	National Plan of Action on food and Nutrition
NVAP	National Vitamin A Supplementation Programme
PMTCT	Prevention of Mother-To-Child Transmission
SAR	Spatial Autoregressive Model
SDG	Sustainable Development Goal

SEM	Spatial Error Model
SLX	Spatial Cross-regressive model
WASH	Water, Sanitation and Hygiene
WAZ	Weight for Age Z-score
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

Background of the Study

The first 59 months of life are critical for the trajectories that affect a child's development. A lot of vital developments occur during this period. These include physical and emotional growth, the ability to socialise and behaviour. Research shows that the first five years are notably crucial for the development of the child's cognitive abilities which contributes to their learning achievements at school and productivity at work (Grantham-McGregor et al., 2007).

Even though children are expected to experience their full development with minor or no complications, this is not the case where there are child health and well-being problems. The issue of child health and well-being, therefore, has been an issue of public health concern for decades (De Groot et al., 2017) considering its long-term implications and recent distribution patterns. According to Bramlett and Blumberg (2007), patterns of health, well-being and socioeconomic status in childhood have marked implications for future outcomes including but not limited to education levels, family status and overall health and well-being. The patterns of ill health, morbidity and mortality among children have raised concerns about the public health implications (Bhutta, 2004; Earls & Carlson, 2001; Maggi et al., 2010). In 2004, it was reported that an estimated 11 million children below the age of 5 died every year (Bhutta, 2004).

Malnutrition in children has contributed immensely to these deaths, and according to De Pee et al. (2009) about 3.5 million of these deaths of children under-five years (every year) are preventable and arise from the problem of malnutrition. Such problems are thought to arise from a range of different factors, including health inequalities emanating from varying patterns of distribution of the different determinants of health (Maggi et al., 2010; Priest et al., 2013).

Global Child Malnutrition

One of the main indicators for public health assessments in the determination of the health and nutritional status of specific populations is child growth and development (de Onis & Blössner, 2003; Wojcicki & Heyman, 2010). An issue of concern is that of childhood malnutrition and the short-, medium- and long-term implications of the problem (Menon et al., 2018). Public health nutrition problems in children include a group of problems emanating from the excessive consumption of required nutrients and food groups, resulting in overweight and obesity (Black et al., 2008). They also include under-nutrition, which is a term encompassing issues such as stunting, wasting and underweight (Black et al., 2008; de Onis et al., 2000; Kerac et al., 2014; Kraak et al., 2012). Assessment of the severity of malnutrition in any individual is facilitated by using anthropometric indices including "weight-for-height"; "height-for-age" and "weight-for-age" ratios (de Onis & Blössner, 2003, p. 32). According to the literature, these indices can be expressed in terms of z-scores, percentiles, or percentages of the median, which enable the comparison of a child or a group of children with a reference population. In addition, children's growth rates relative to recognised averages for age and gender can also be used to assess child development.

Stunting, which refers to a height-for-age z-score less than two standard deviations of the World Health Organization (WHO) child growth standard median, is also known as chronic malnutrition (WHO, 2006). It is often associated with a poor quantity and quality of protein in children's diets and is assessed using the length or height of the child in comparison to recommended averages for their age and gender as recommended by the WHO's own Child Growth Standards (de Onis & Branca, 2016). Stunting, a widely used index for depicting the prevalence of malnutrition in early childhood and its long-term consequences include adverse effects on cognitive development, education outcome and economic productivity in adulthood, which results in lower incomes and maternal reproductive outcomes (Dewey & Begum, 2011; Victora et al., 2008). Zere and McIntyre (2003) reported that the most common form of malnutrition in children in most parts of Africa was stunting. Ahmed et al. (2012) further highlighted this with their reports of marked increases in occurrences of stunting and chronic malnutrition among children in Africa, with relatively high numbers of children also suffering from chronic stunting in Asia.

Although the recent years have seen a notable decline in stunting in most parts of the world, the prevailing rates are still above globally desired rates and therefore a cause for profound worry. Globally, there has been a decline in stunting rates from 32.7 per cent in 2000 to 22.2 per cent in 2017. Asia saw a 39 per cent decline – from 38.1 per cent in 2000 to 23.2 per cent in 2017. However, within the same period, Africa recorded a 20.9 per cent decline from 38.3 per cent to 30.3 per cent (UNICEF, 2018).

An estimated 7.7 per cent – or 52million children under the age of 5 – suffer from wasting as indicated by a low weight-for-height ratio as well as a relatively low mid-upper arm circumference, with up to 18.7 million suffering from severe wasting in 2016 (UNICEF, 2018).

Currently, at least one in three children under 5 years is stunted, wasted or overweight. In 2018, about 540 million children under five suffered from malnutrition. Around 149 million were stunted (with the most significant numbers of affecting children residing in Sub-Saharan Africa), almost 50 million wasted, 40 million overweight and at least 340 million suffering from deficiencies of essential micronutrients, including vitamins and minerals (UNICEF, 2019). Although these numbers depict an amelioration of child health conditions, the number of children with a poor health condition in the 21st century is an unpleasant surprise. It is stated that this prevalence in developing countries is a reflection of the fact that children's diets in these areas are often highly dependent on commonly available staple foods (e.g. cassava and maize) that are relatively poor sources of the required amino acids (Semba, 2016).

According to the WHO, the problem of malnutrition is one of the main factors contributing to recent increases in global ill health, morbidity and mortality among children (Kerac et al., 2014; Wojcicki & Heyman, 2010). In addition to the increased risk of mortality that is associated with poor anthropometric measures, it is also recognised that there are problems of poor mental development and intellectual ability associated with poor growth in children (de Onis & Blössner, 2003; Semba, 2016). Other problems include increased susceptibility to health conditions like diarrhoea and varied infections (de Onis & Blössner, 2003).

Furthermore, while it is acknowledged that the treatment and active management of malnutrition can significantly improve the health of the targeted populations; it is also recognised that it is not always possible to identify malnutrition as one of the key underlying causes of morbidity or mortality in individuals (Jackson et al., 2006). However, it must be noted that the use of uniform anthropometric measurements and scales – as developed by organisations like the WHO – helps significantly with the identification of the problem and facilitates the development, implementation and maintenance of measures that can contribute to significant improvements in general nutrition, health and well-being of children within a specific region (Ahmed et al., 2012; Semba, 2016).

Traditionally, interventions targeting nutrition were often focused on two main determinants: health status and levels of food intake by targeted populations (De Groot et al., 2017). However, it is now increasingly recognised that in the first 2 years of a child's life, linear growth rates could be greatly influenced by potentially amendable factors in their surrounding social, economic, cultural and other environments. (Bernard et al., 2007b; de Onis & Branca, 2016; Earls & Carlson, 2001; Maggi et al., 2010). De Groot et al. (2017) highlight the fact that maternal health and well-being, household earning power and resources as well as changes in the wider economic environment can potentially influence malnutrition in children. This occurs through the interactions between these different determinants and as a result of factors like the relationships within families, children and their peers as well as other environments (schools, churches, daycare) that the children engage with on a routine basis (Maggi et al., 2010). For any specific location, therefore, it is important to develop insights into the main factors contributing to patterns of malnutrition as a means of facilitating the development and implementation of suitable interventions. This leads us to the question of the role of neighbourhood or place in child growth and nutrition, which is the focus of this study.

Statement of the Problem

The ineluctable role of location and spatial interaction on health status in social science and health literature is well established (O′Campo et al., 2015; Cummins et al., 2007). Studies have also shown spatial variations in factors that drive health outcomes (Bissonnette et al., 2012). The empirical investigation of this study is classified into three chapters. The first uses a range of statistical methods to ascertain child health inequalities and disparities in Ghana and the neighbourhood's effect on child health. These methods include logistic regression, multilevel logistic regression, ordinary least squares (OLS) regression, spatial data analysis (exploratory spatial data analysis (ESDA)) and spatial regressions (Spatial Lag Model, Spatial Error Model and spatial cross-regressive model). The second empirical chapter uses structural equation modelling for the measurement of spatial effects on child health in the absence of spatial weights. The third considers a broader perspective by using data from 30 Sub-Saharan African countries to look at disparities. These methods are intended to fill certain gaps in literature while taking into account the role of location on child health. The following, therefore, are the gaps in the literature for each empirical chapter.

With regards to the first empirical chapter, the existing literature on child health in Ghana has ignored the spatial factor. It has concentrated on factors which do not address the issue of disparities. These studies have focused on individual-level factors such as dietary diversity (Frempong & Annim, 2017), household nucleation (Annim et al, 2015), the child's age, the number of children in the household and mother's age (Darteh et al., 2014).

However, there is a growing body of works from different parts of the world that have identified a significant association between the place of residence and health in addition to individual-level factors (Diez Roux, 2001; Humphreys & Carr-Hill, 1991). This relationship has been examined for variations in health outcomes such as overall health outcome (Tabb et al., 2018), stunting in children (Adekanmbi et al., 2013), childhood morbidity (Kandala et al., 2007) and birth defects or congenital disabilities (Rushton & Lolonis, 1996; Wu et al., 2004). The concept of place has also been considered in criminology studies in which the spatial patterning of homicide rates were studied (Messner et al., 1999).

In conceptualising the relationship between health and place, some studies consider the externality of information through social networks or social interactions (Topa & Zenou, 2014) and the differences in the distribution of resources (Bernard et al., 2007b). Bernard et al. (2007) combine Gidden's structuration theory (Giddens, 1991) and Godbout's theory of informal reciprocity (Godbout & Caille, 1998) to provide a framework for explaining the mechanisms by which resource availability varies, resulting in differential benefits for different people and contributing to health inequalities. The framework explains the accessibility of health-related resources through five main domains: “physical”, “economic”, “institutional”, “local sociability” and “community organisation”. This also adopts the concept of social networks and further distinguishes between two related uses: mobilization for pursuing collective goals (community organisation) and procurement of individual benefits, particularly information and social support (local sociability). However, it is prudent to examine child health inequalities with regards to place, premised on the concepts of externalities, social capital, geographical proximity and, most importantly, Tobler’s First Law of Geography, which postulates that “everything is related to everything else, but near things are more related than distant things” (Tobler, 1970).

Given the paucity of research related to this problem in Ghana, the first chapter intends to examine the district and cluster-level spatial patterns of under 5 childhood stunting in Ghana and find the level of spatial dependence. The chapter sets itself apart from other studies on malnutrition in children in Ghana, since several econometric tools were used to deal with variations in stunting across areas and by incorporating spatial dependence in the models.

The second empirical chapter explores an alternative way of measuring spatial dependence or spatial effect on child health in the absence of unique locations for individual observations. Despite evidence in the literature of the need to apply spatial econometric models to measure spatial dependence in health and other social studies (Anselin, 1988, 1990, 2017; Messner et al., 1999), this has over the years become almost impossible empirically, especially with health studies at the individual level. Most internationally recognised and nationally representative survey data, like the Demographic and Health Surveys (DHS) assure and protect respondents’ anonymity. These data thus provide no unique locations of respondents which are key in spatial analysis and spatial econometric models. With respect to DHS datasets, GPS locations exist for only groups of households (called 'clusters') and not for individual respondents or households. In the absence of this data, most empirical studies on child health analysed at the individual level pay little or no attention to spatial dependence and do not apply spatial econometric models (Annim et al., 2015; Darteh et al., 2014; Frempong & Annim, 2017). Studies that had considered spatial dependence on health and used spatial econometric tools studied cluster-, state- or district-level effects (Adekanmbi et al., 2013; Aheto et al., 2017).

In the second empirical chapter, the study uses the latent variable approach to modelling spatial dependence devised by Oud & Folmer (2008), where the observed values of key neighbouring and environmental variables are indicators. This approach provides a more informative and flexible presentation of spatial dependence than the conventional approach by using a weight matrix. The chapter also uses a full information maximum likelihood estimator, where coefficients of key variables of interest are estimated by means of a simultaneous equations model framework and interactions among variables are taken into account.

Concerning the third empirical chapter, several studies underscore improved water as a useful intervention to improve child health (Dangour et al., 2013; Fink et al., 2011; Taylor et al., 2015). However, there is conflicting conclusions on the effect of such interventions (Bain et al., 2012; Godfrey et al., 2011; Headey & Palloni, 2019; Shaheed et al., 2014). According to these studies, improved water may not always be safe due to factors like contamination associated with storage and pollution. It is acknowledged that most of these papers that examine the effects of improved water on child health fail to consider the dissimilarities in areas (concerning water shortages, environmental characteristics) that mediate the effect of improved water. This therefore calls for further research on the effect of improved water on child health with appropriate models that take into account the varying characteristics of location.

Objectives of the Study

Generally, the study seeks to examine the effect of spatial dependence on early child health with specific focus on neighbourhood mothers' education, WHO's improved water and the methodological shortfalls of excluding neighbourhood effects. Specifically, the study seeks to:

1. Assess spatial dependence of stunting in children.
2. Examine the effects of neighbouring mothers' education on child health.
3. Investigate differences in the neighbourhood effects of the correlates of stunting.

The first two objectives constitute the first and second empirical chapters and focus on Ghana. With a clear methodological distinction, the second empirical chapter further examines the effect of socioeconomically advantaged neighbourhoods on child health and pathways through which neighbouring mothers' education affects child health. The third objective is based on Sub-Saharan Africa and makes the third empirical chapter. It looks into the extent to which the neighbourhood effects of the correlates of stunting, specifically, proportion of mothers' education and improved water on stunting varies.

Hypotheses

Given the objectives, the study hypothesises that:

1. Stunting in a district or cluster or an individual is positively influenced by their neighbours' observed and unobserved characteristics.
2. Neighbouring mothers' education reduces stunting over and above own mother's education.
3. The neighbourhood effects of the correlates of stunting (mothers' education and improved water) are not homogenous.

The first two hypotheses, test the objectives for the first empirical chapter at the district- and cluster-level. These are tested again in the second empirical chapter at the individual level, using alternative method and considering the pathways through which the correlates of malnutrition indicators jointly affects an individual. The third hypothesis is the main hypotheses for the third empirical chapter.

Significance of the Study

The findings of this study will provide benefits to public health practitioners, policymakers and other researchers considering the challenges posed by health inequalities and the critical role of neighbouring characteristics. The persistence of differences in health status or distribution of health resources explains the need for more explicit studies into health inequalities. With the application of appropriate models and more robust techniques, this study provides information on districts and areas with high-risk incidence of stunting, which would assist in area-specific interventions.

This can, in turn, contribute to the attainment of the Sustainable Development Goal (SDG) 3, which seeks to ensure healthy lives and promote well-being for all.

The main categories of health, social group and geographic inequalities which sometimes affect health differences across individuals are considered holistically in the models used, providing a convenient way of understanding the complexity of child health and its associate disparities.

Scope of the Study

The study examines the impact of neighbourhoods or place of residence on child health outcomes in Ghana and Sub-Saharan Africa with a particular focus on neighbourhood mothers' education and neighbourhood wealth status. It employs the recent Ghana DHS data (2014 survey year) to estimate neighbourhood effects at the individual-, cluster- and district-level. Due to the year of the survey data used in the first and second empirical chapters, this study limits all administrative areas in Ghana to the numbers created as at 2014. The study, therefore, considers ten (10) regions and two hundred and sixteen (216) districts (*New Districts and Nominated DCEs*, 2013).

The study also employs the most recent DHS datasets from thirty (30) countries from Sub-Saharan Africa with survey years ranging from 2010 to 2016. The study applies spatial analysis, multilevel modelling and structural equation modelling to achieve its outlined objectives. The sample understudy is 59-month- old children and below.

Contribution to Literature

The present study contributes to the existing literature on child health inequalities and neighbourhood effects in Ghana and Sub-Saharan Africa. This section presents the contributions made in the empirical chapters of the study: (1) spatial clustering and neighbourhood effects of stunting in Ghana; (2) a structural equation modelling approach to examining the effect of neighbourhoods on child health in Ghana; and (3) multilevel and spatial analysis of child health in the Sub-Saharan context.

The first empirical chapter provides a fundamental reflection of the distribution of stunting in Ghana. It provides evidence of apparent health inequalities by presenting specific high-risk areas and districts in Ghana. The chapter looks beyond the simplicity of examining child nutritional outcomes (stunting) with standard econometric tools on individual-level risk factors. It pushes against the treatment of spatial dependence and spatial heterogeneity – which are common in geographic or cross-sectional data – as nuisance (Anselin, 2003), to incorporating spatial factors in the understanding of the context of health inequalities. The study argues for the need to explicitly account for the interaction of economic agents that leads to spatial dependence in examining child health inequalities.

The second empirical chapter makes essential methodological and empirical contributions to the study of health by incorporating the concept of spatial dependence (also termed neighbourhood effects) into a structural equation model. It provides an alternative to measuring spatial dependence in the absence of individual-level unique geographic information. For each observation, the study generates neighbouring factors within the same cluster without the observation itself to model relationships between observed variables and the underlying latent factor (spatial effect). In modelling child health outcomes (height-for-age and weight-for-age ratios), the study incorporates Anselin's (1988) standard spatial lag model in its structural equation model (Oud & Folmer, 2008) to simultaneously examine the unequal spatial factors and a system of interrelating risk factors. The operationalization of this study through the lens of intersectionality allows for a more practical specification where different social determinants of health intersect to influence an individual's health. Most importantly, the study brings to bear the substantive effect and possible pathways of neighbourhood characteristics, such as neighbouring mothers' education and neighbours' wealth.

The study reiterates the importance of mothers' education on child health – which has been extensively researched – premised on the SDG 4 to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" and SDG 5 to "achieve gender equality and empower all women and girls". However, unlike other studies that have looked at child health and the importance of an individual's own mothers' education, this study provides a greater perspective on the importance of women's education by examining neighbouring mothers' education in addition to an individual's own mother's education. The study thus extensively positions the importance of the education of women, which does not just benefit their own offspring but also that of children who live close by or in the same community. The findings show further evidence of the effect of mothers' education on child health and succinctly provide insight into the salience of this association, which is often overlooked in research.

In the era of 'big data' where 'large' studies have proven to be more reliable than small ones (Pence, 2014) and crucial for government organisations (Richards, 2017), the third empirical chapter contributes to the existing literature on health inequalities by considering Sub-Saharan Africa with a sample of 245,426 children below the age of 5 years. The study again identifies specific stunted clusters in Sub-Saharan Africa. Unlike other studies on child health and the effect of improved water sources, the study uses a more efficient random slope model, thereby positing that the effect of improved water on child health varies across neighbourhoods.

Limitations of the Study

The study contributes to the developing literature on child health inequalities and the role of neighbourhood and socioeconomic conditions on child health. Nevertheless, two main potential limitations are noted regarding some components of the overall strategy adopted to address the research objectives, with respect to data and methods.

A primary limitation of the study is the non-availability of unique locations or geographical coordinates of households or residence of individual children in the data. The DHS data only provides unique geographical information on clusters and not on households or individuals. This required that all analysis involving spatial regressions are restricted to cluster and district level since spatial regressions necessitate the use of a unique location for each observation. Be that as it may, results obtained with other models, including the multilevel regression models used in the study, show spatial variations of health outcomes and the role of neighbourhoods on child health.

The study employed a cross sectional design with the most current survey data used from 2016. Hence, the analysis did not consider any potential differences with time. Nonetheless, several econometric analyses and methods were employed to sufficiently show the effect of neighbourhoods or locations on child health, which has little to do with time.

Organisation of the Study

The study consists of eight extensive chapters. The following is an overview of the structure and content. The next chapter provides an overview of trends and policies with regards to child health in Ghana. Chapter three reviews the pertinent literature both on the theoretical and empirical relationship between neighbourhood characteristics and health. A description of the data used and the empirical strategy are presented in Chapter four. The first empirical study and its estimated results on spatial analysis of child health inequality in Ghana is presented in Chapter five. In Chapter six, the study proposes and estimates a structural equation model to examine the effects of neighbourhoods on child health outcomes for the second empirical chapter. The seventh chapter considers a broader horizon by examining the effects of neighbourhood contexts using thirty (30) countries in Sub-Saharan Africa. Chapter eight concludes the study and presents a summary and recommendations.

CHAPTER TWO

OVERVIEW OF CHILD HEALTH IN GHANA AND SUB-SAHARAN AFRICA

Introduction

This chapter provides an overview of trends in child health since 1988, and the policies and issues of inequality in Ghana. It also provides a brief review with regard to Sub-Saharan Africa. The analysis on trends is based on all rounds of the GDHS (I-VI). Six rounds of the survey have been conducted so far. The first was conducted in 1988, the second was in 1993 and the third, fourth, fifth and sixth were conducted in 1998, 2003, 2008 and 2014 respectively.

The review begins with trends and analysis of child health in Ghana from 1988 through to 2014 using a sample of children aged 0 to 59 months. This is followed by a review of the fight against child malnutrition and ill health in Ghana, with focus on the policies that have been adopted over the years to help mitigate the problem. Finally, despite the strides made, the chapter looks at some failures with regards to regional disparities and rural-urban disparities. The chapter will conclude with a brief overview of child health in Sub-Saharan Africa.

Trends and Analysis of Child Health in Ghana

Policymakers, public health practitioners and researchers continue to place emphasis on the nutritional status of children as a key contributor to the overall health of a child. This is due to the fact that nutritional status defines an individual's health, which is a pertinent issue in the SDGs' agenda, through

SDG 3 and also because it is closely related to several targets in the other goals. Malnutrition constitutes about 45 per cent of deaths in children under 5 years old and hinders their full development (WHO, 2019). According to the WHO's Commission on Information and Accountability for Women's and Children's Health, aligned with the indicators of the Millennium Development Goals (MDGs) and still accepted today, stunting, wasting and underweight constitute the core impact indicators of neonatal and child health (WHO, 2013). Children suffering from stunting may never grow to their full potential, starting their lives with disadvantages that can include learning difficulties at school and barriers to participation in their communities. West Africa has 31.4 per cent of stunting rate, accounting for half of the stunting rates in Africa. There were 4 million cases more of stunted children in West Africa in 2016 than in 2000 (WHO et al., 2017). Meanwhile, children suffering from wasting have weakened immunity, are susceptible to long-term developmental delays and face increased risk of death. In West Africa, the United Nations had estimated that 8.5 per cent of children suffering from moderate to severe wasting.

In Ghana, malnutrition rates (stunting, wasting and underweight) among children less than 5 years have declined significantly since 1988. Figure 1 presents trends of malnutrition in children less than 5 years old according to the six rounds of the GDHS. The graph shows that the rate of stunted children has declined steadily over the years. In 1988, the country recorded that 34 per cent of children were stunted, 23 per cent were wasted and 9 per cent were underweight. The prevalence of stunting continued to decline from 33 per cent in 1993 to 31 per cent in 2003 and then 28 per cent in

2008. As of 2014, the prevalence of stunting had declined to 19 per cent, lower than the 2014 global prevalence of stunting of 24 per cent (UNICEF et al., 2020). The prevalence of underweight also decreased appreciably from 1988 through to 2014. Although there was no change from a rate of 23 per cent in 1988 to 1993, the proportion of children under 5 who are underweight declined in 1998 with a rate of 20 per cent, and then 18 per cent and 14 per cent in 1998 and 2003 respectively. In 2008, there was about 22.2 per cent fall and a further fall in 2014 to 5 per cent, which is also significantly less than the average prevalence rate of developing countries. However, the national prevalence of wasting shows a different trend. In 1993, Ghana's under 5 wasting prevalence had risen to 14 per cent from 9 per cent in 1988. It then began to fall in 1998, recording 10 per cent and further decreasing in 2003 with a prevalence rate of 8 per cent. While this shows an improvement over the period after 1993 and ending 2003, wasting worsened afterwards. The prevalence of wasting increased to 9 per cent in 2008 and 11 per cent in 2014 – less than the 8.9 per cent average for developing countries.

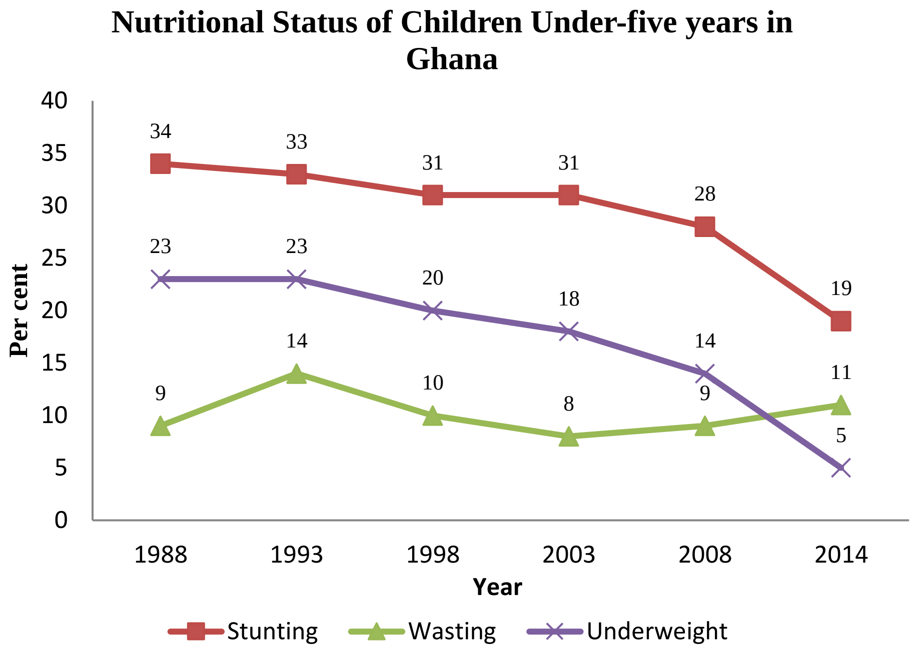


Figure 1: Nutritional Status of Children under 5 in Ghana from 1988 to 2014

Source: Agyen (2020)

Ghana has undoubtedly shown improvement with respect to malnutrition indicators (stunting, wasting and underweight). For the purpose of comparison, Figure 2 presents the prevalence of stunting for 29 Sub-Saharan African countries, including Ghana. The graph shows that Ghana performed well against other Sub-Saharan African countries.

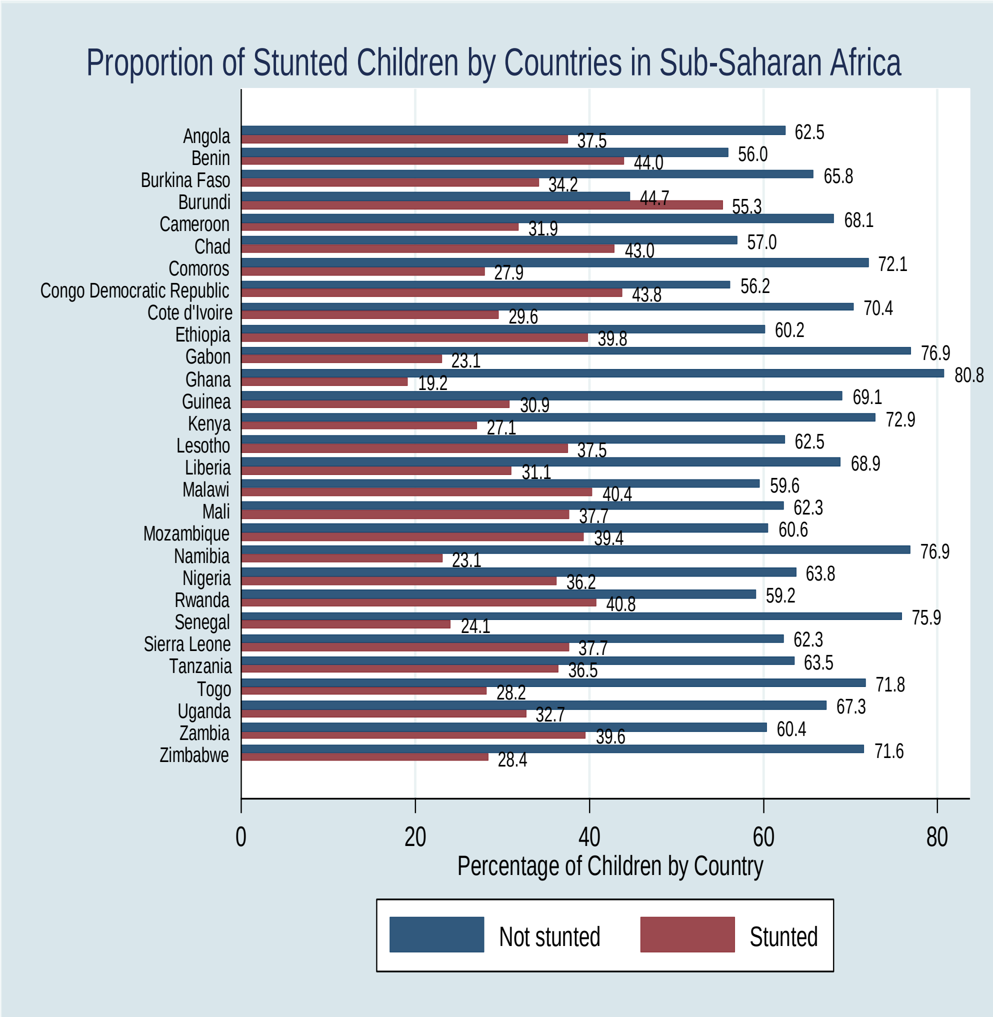


Figure 2: Distribution of Stunted Children across Sub-Saharan African Countries as at 2016

Source: Agyen (2020).

The country also performed well against several other Sub-Saharan African countries with respect to the prevalence of wasting (see Appendix A) and underweight (see Appendix B).

The regional office of the WHO in Ghana reported that neonatal mortality makes up 71 per cent of infant mortality and 48 per cent of under 5 mortality (WHO, 2018b). According to the UN Maternal Mortality Estimation Inter-Agency Group (2015) and the GDHS (2014) the indicators of maternal and child health include the following: skilled delivery childbirth between 50 per cent to 74 per cent; neonatal tetanus prevention, 74 per cent; neonatal mortality rate 29/1,000 live births; infant mortality rate, 41/1,000 live births; under 5 mortality rate, 60/1,000 live births; contraceptive prevalence of 22.2 per cent; and adolescent pregnancy rate, 14 per cent (MMEIG, 2015). Further indicators of child health in Ghana included in the Nutrition Landscape Information System (NLiS) indicate that low birth weight (<2500g) in Ghana is 14.2 per cent and anaemia in children below 5 years old (Hb <110g/L) reaches up to 66. 9 per cent (Abarca-Gómez et al., 2017).

Nutrition-Related Policies in Ghana, 1992 - Present

Several policies have been implemented in the fight against child malnutrition and ill health in Ghana. The Nutritional Landscape Information System (NLiS), first published in 2010 and the Global Database on the Implementation of Nutrition Actions (GINA), provide a catalogue of nutrition policies and interventions across the globe, including Ghana (WHO, 2010b).

Table 1: Nutrition Policies in Ghana from 1995 to 2014

Policy Title	Start Year
National Nutrition Policy 2014 - 2017	2014
Health Sector Medium-Term Development Plan 2014 - 2017	2014
Strategy for the Management, Prevention and Control of Chronic Non-Communicable Diseases in Ghana	2012
Medium-Term Development Policy Framework, Ghana Shared Growth and Development Agenda (GSGDA, 2010 - 2013)	2010
Health Sector Medium Term Plan	2010
Under Five's Child Health Policy 2007 - 2015	2007
Creating Wealth through Health	2007
National Health Policy: Creating Wealth through Health	2007
Growth and Poverty Reduction Strategy (GPRSII)	2006
Imagine Ghana Free of Malnutrition	2005
Integrated Anaemia Control Strategy	2003
National Reproductive Health Service Policy and Standards	2003
Breastfeeding Promotion Regulations 2000, LI1667	2000
Vitamin A Policy	1998
Breastfeeding Promotion Regulations	1995
Food and Drug Law and Amendments: Universal Salt Iodisation	1995
National Plan of Action on Food and Nutrition	1995
Food and Drugs Act. 199	1992

Source: NLiS/GINA (WHO, 2018a)

In 1995, the Ministry of Agriculture adopted the National Plan of Action on Food and Nutrition (NPAN). The overall aim was to improve the quality of life for all Ghanaians and specifically to improve the nutritional status of all. Although this policy was generic rather than child-specific, the 11 programs planned and implemented had some child-specific ones outlined. The programs with regard to child nutrition focused on the promotion of ideal breastfeeding practices and the promotion of appropriate weaning practices. Some other programs under this policy that sort to improve health including that of children, involved improvements in household food security, increasing food or nutrient intake for individuals, the promotion of good hygiene practices and capacity building for food and nutrition related to education and services (WHO, n.d.). In the same year, the Food and Drug Law and Amendments adopted the Universal Salt Iodisation, which was aimed at eliminating iodine deficiencies (WHO, 2009).

The Breastfeeding Promotion Regulation was equally adopted in 1995 and revised later in 2000. The policy was intended to prohibit the sale of selected products (for example, infant formulas and products presented as breastmilk substitutes for feeding infants, not more than six months) in any health care facility. Initially, feeding bottles and infant formulas and foods were common items sold in hospital shops and clinics. The regulation postulated that in addition to a restriction on sales, the advertising and promotion of these products was also not permitted in any health care facility. It also prohibited the manufacturing and distribution of products and educational materials related to infant feeding or young children within the scope of the regulations unless the material was first approved by the Food and Drugs Board. The Ghana National Breastfeeding Promotion Regulation Committee was set up and tasked with coordinating investigations into allegations of violations of the regulations. The committee reported to the Ministry of Health.

The National Vitamin A supplementation programme (NVAP) started mass supplementation in the three most vitamin A-deficient regions of northern Ghana (Northern, Upper East and Upper West) during 1997. A year later, the vitamin A policy was adopted and the distribution was extended to all ten regions of Ghana. *The Lancet*'s nutrition series lists vitamin A supplementation among the main interventions achievable at a large scale that can prevent child death (Yawson et al., 2017).

The Ghana Health Service, in collaboration with local stakeholders and the support of the United States Agency for International Development (USAID), established a five-year Integrated Anaemia Control Strategy, adopted in 2003. The project targeted pregnant women, preschool and school-aged children with food-based interventions. Furthermore, the strategy included interventions to control malaria and helminthic infection. Later, in 2005 the Director-General of Ghana Health Service (GHS) facilitated the formulation of strategies and a concept paper titled 'Imagine Ghana Free of Malnutrition'. This paper was focused on addressing malnutrition in Ghana as a development problem, using health as the entry point. The concept paper aimed at analysing the role of the health sector and the GHS at gathering together all relevant development partners, non-governmental organizations (NGOs) and the private sector in order to address the high levels of malnutrition in Ghana (GHS, 2005; 2016). This was a follow-up to the previous 1995 NPAN. However, with the change of the Director-General, the concept paper lacked support for its implementation, and the document remained as a guiding policy for actions on nutrition.

The Ministry of Health indicated that the majority of child deaths in Ghana are caused by conditions that are preventable or treatable with simple, low-cost interventions. This was the fundamental reason behind the development of the Under Five's Child Health Policy 2007–2 015; to use such interventions in the fight of child deaths. The policy included interventions to improve child health in different technical areas where some of such interventions were delivered by different programmes and policies already documented. The Child Health Policy referenced existing policies and advocated for a ‘child-centred’ policy framework rather than a ‘programme centred’ approach. The document highlighted that in order to improve the health indicators, different programme areas needed to collaborate. The technical interventions of the ‘continuum of care’ included four areas: (1) pregnancy, (2) delivery and immediate post-delivery period, (3) neonatal period, and (4) infants and children.

In line with pregnancy-related programs, the Under Five’s Child Health Policy 2007–2015 pointed to interventions such as prenatal nutrition, including iron and folate supplementation; at least two doses of intermittent preventive treatment for malaria; promotion of insecticide-treated bed net (ITN) use for pregnant women; detection and treatment of problems complicating pregnancy as well as birth and post-birth preparedness. In the second level of intervention, which is considered the immediate post-delivery period, attention was drawn to the first hour after birth as well as skilled birth care and emergency obstetric and newborn care (EmONC). During the neonatal period (from birth to 28 days of life), the document highlights exclusive breastfeeding, thermal care (including kangaroo mother care), hygienic cord care, prompt care-seeking for illness, management of the sick newborn (including sepsis, asphyxia and prematurity), prevention of mother-to-child transmission (PMTCT) of the human immunodeficiency virus (HIV), immunizations and screening for sickle cell anaemia. Finally, for infants and children, interventions were divided into preventive and treatment. The preventive interventions included exclusive breastfeeding for 6 months, continuous use of ITNs, continued breastfeeding to 2 years, complete vaccination by 12 months (polio, diphtheria, pertussis, tetanus, Haemophilus influence type [Hib], hepatitis B, measles, yellow fever and new vaccines as per Expanded Programme on Immunization [EPI] policy), vitamin A supplementation, and consumption of iodated salt. In the treatment interventions the policy included anti-malarials, zinc for diarrhoea, antibiotics and zinc for dysentery, antibiotics for pneumonia, vitamin A for measles and the management of malnutrition.

The Ghana National Nutrition Policy (NNP) 2014–2017 was also initiated to promote the integration of nutrition interventions within existing facility and community-based maternal, newborn and child health services. The NNP was to provide an overarching multi-sectoral framework for attaining the ideal nourishment and mitigating issues of malnutrition for all people in Ghana. To achieve this goal, the policy specifically outlined these sub-objectives: (1) to increase coverage of high-impact nutrition-specific interventions that ensure optimal nutrition of Ghanaians throughout their lifecycle, with special reference to maternal health and child survival; (2) to ensure high coverage of nutrition-sensitive interventions to address the underlying causes of malnutrition; and (3) to reposition nutrition as a priority multi-sectoral development issue in Ghana. In accordance with these objectives, the policy measures included: (a) promotion of nutrition of women of reproductive age and the newborn through food-based and micronutrient interventions; (b) promotion of optimal nutrition during infancy and childhood through support for exclusive breastfeeding, intake of micronutrients and diversified foods, and measures on maternity leave (implementation of six-month maternity leave); (c) prevention and management of acute malnutrition through the delivery and accessibility of quality health and nutrition services; (d) ensuring the prevention of infectious diseases through water, sanitation and hygiene (WASH) programs; and (e) on education; promotion of girls' education, facilitating the integration of nutrition into school curricula and the provision of school meals that meets the nutritional needs for targeted age groups.

The NNP 2014–2017 policy also highlighted that its successful implementation required effective multi-sectoral action, partnership and coordination, involving key ministries, departments, and agencies (MDAs); research institutions and academia; civil society organizations (CSOs); and the private sector. These objectives and plans for implementation were premised on some key guiding principles. First, the primary assertion was that adequate nutrition is a universal human right. The right to access safe and nutritious diets was maintained to fit in the fundamental basic right of all to be free from malnutrition and associated disorders. It also indicated nutrition as a priority issue for human development. In addition to the effective inter-sectoral partnership and coordination, there was gender consideration and special attention paid to the needs of all vulnerable groups. Next is the evidenced-based and effective intervention principle. Implementation was to be based on techniques and best practices that had been scientifically evaluated. Premised on equality principles, the policy sought the decentralization of resources and interventions. In order to achieve better outcomes for various communities, nutrition interventions and activities were to be channelled through a decentralized governance system. Finally, community empowerment and participation were adhered to in order to yield beneficial outcomes and enhance community ownership and acceptance. The design was based on the community collaboration and empowerment in the delivery of nutritional information and resources.

The Ghana National Newborn Health Strategy and Action Plan 2014–2018 was developed with the aim of decreasing neonatal mortality by ensuring that national efforts placed adequate focus on protecting the health of newborns. The intent of the plan was to guide leaders to develop and implement activities within the existing Ghana MDG, Acceleration Framework Action Plan, and the Ghana National Reproductive, Maternal, Neonatal and Child Health framework. The principal goals were to reduce the number of babies who die in the neonatal period from 32/1,000 live births in 2011 to 21/1,000 live births in 2018 (a 5 per cent decrease per year), and to reduce institutional neonatal mortality by at least 35 per cent by 2018 (GHS, 2014).

As has been outlined in this section, current national efforts to reduce nutritional deficiencies in Ghana have made progress over the past decade. The effects are reflected in the 2014 GDHS. Infant mortality declined from 77/1,000 live births in 1988 to 41/1,000 in 2014; under 5 mortality declined from 155 to 60 deaths per 1,000 live births over the same period (Yawson et al., 2017). The improvements at the national level are important, but inequities in malnutrition status still persist in certain geographical locations (districts and regions) within the country (GSS, 2014).

On the global front, the first Global Nutrition Policy Review (GNPR) was undertaken in 2009-2010, and it served as a background paper for the Comprehensive Implementation Plan on Maternal, Infant and Young Child Nutrition adopted by the WHO Assembly in 2012. The second GNPR took place in 2016/17 and was published in 2018 along with six global nutrition targets to be reached by 2025. The targets included the reduction of child stunting and wasting as well as reductions in maternal anaemia, low birth weight, and increases in breastfeeding (WHO, 2018a). In 2014 the member states committed to the Rome Declaration on Nutrition (in the Second International Conference on Nutrition [ICN2]) in which a common vision for global action was articulated, including the six global targets for 2025. These initiatives have been undertaken in the context of the UN Decade of Action on Nutrition (2016–2025).

In August 2019, a strategic plan to reduce malnutrition in Africa was adopted by WHO member states. The plan which was adopted at the 69th regional committee meeting for WHO Africa, outlined strategies to end hunger and all forms of malnutrition by 2030. The plan included the mobilization of resources to support research and advocacy for 90 per cent coverage of investment into the ten highest impact nutrition interventions.

Despite the huge strides that have been made after these policies, malnutrition rates are still high and of much concern to policy makers. One pressing issue is the differences across subgroups, which are discussed in the next section.

Inequalities in Child Malnutrition in Ghana and Sub-Saharan Africa

The Ghanaian context

Ghana, like most Sub-Saharan African countries, has seen a considerable decline in child malnutrition over the years. However, vast disparities still persist even within regions with low prevalence. Despite the relatively low prevalence of stunting in Ghana (compared to other Sub-Saharan African countries), some regions of the country record considerably higher rates. Figure 3 shows large variations across the regions of Ghana; varying between 14 per cent in the opposite direction in the Northern region to about 9 per cent in the Greater Accra region. In addition to regional disparities, a comparison of rural-urban nutritional status of children also reveals the existence of hidden within-country inequalities.

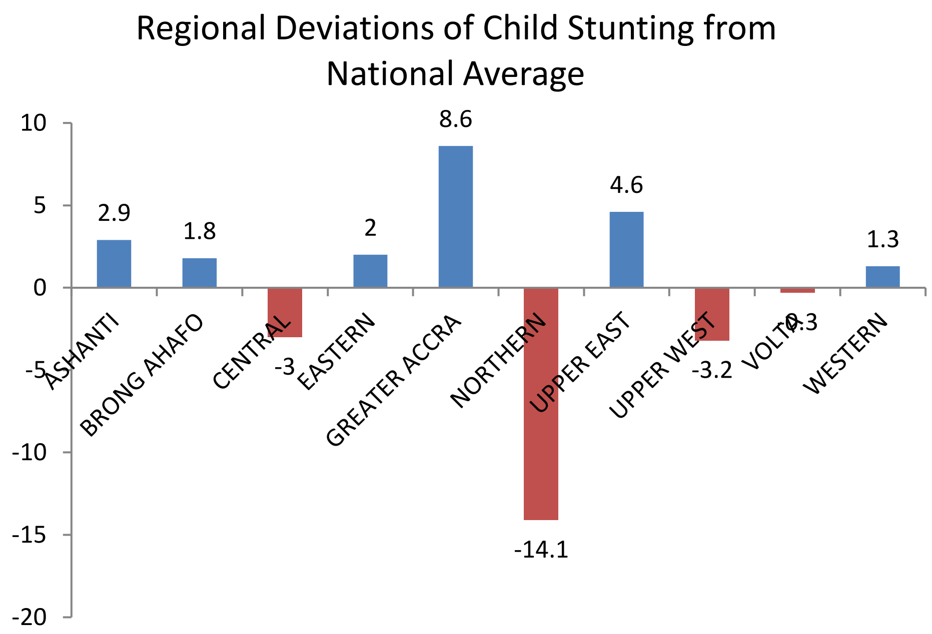


Figure 3: Stunting deviation and regional inequalities in Ghana

Source: Agyen (2020)

About 70 per cent of stunted children in Ghana are found in rural areas, while 30 per cent are from urban areas (see Appendix D). Figure 4 presents the distribution of stunted children across residential communities (rural and urban) in Ghana. The graph shows that the prevalence of stunting is relatively high in rural areas compared to urban areas. In fact, with the exception of the Greater Accra and the Ashanti regions, which recorded relatively low proportions of stunted children in rural areas (Greater Accra, 15 per cent and Ashanti, 42.1 per cent) compared to their respective urban areas' proportions (Greater Accra, 87 per cent and Ashanti, 57.9 per cent), all the regions saw higher proportions of stunted children in the rural areas compared to the urban areas. This is evidence of rural-urban disparities with regards to stunting. The exceptional case of the Greater Accra and Ashanti regions could be explained by the significant difference in the proportion of children living and sampled in urban areas compared to the rural areas in these regions (see Appendix C).

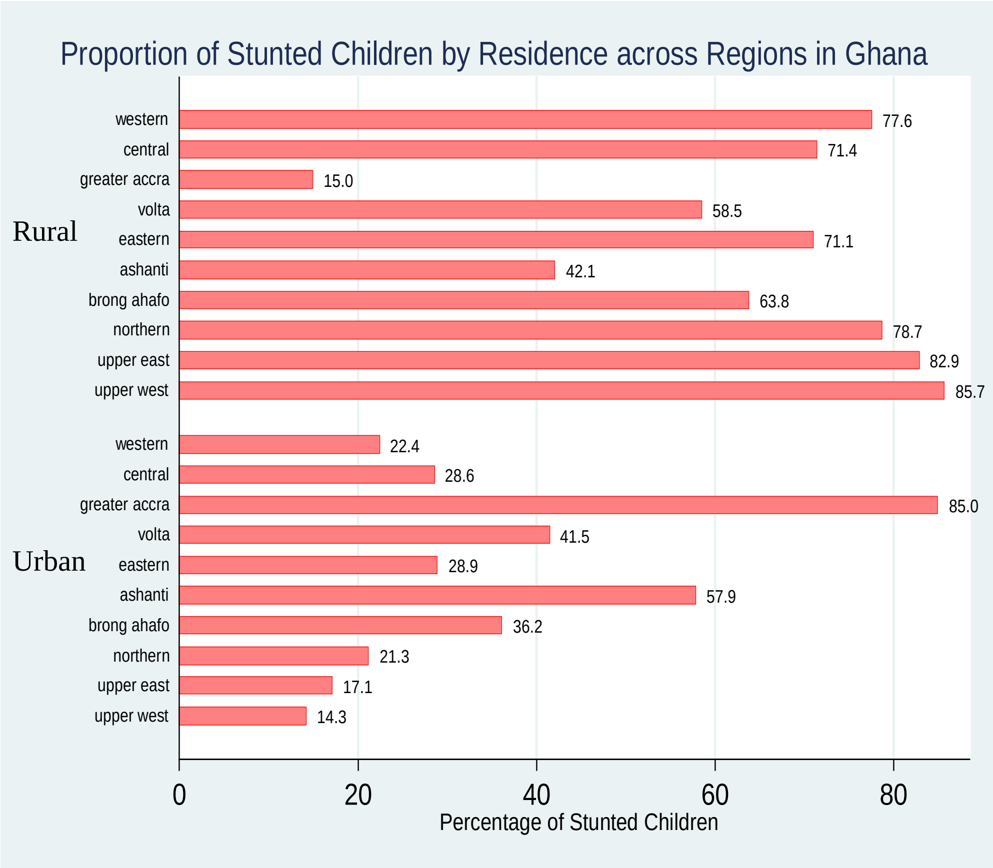


Figure 4: Distribution of stunted children by regional residence (urban-rural) across regions in Ghana

Source: Agyen (2020)

With regards to wasting, about 67 per cent of wasted children reside in rural areas, while 33 per cent are found in urban areas. Again, Appendix D shows that approximately 69 per cent of under 5 underweight children in Ghana resides in rural areas, while 31 per cent reside in urban communities.

According to *The Lancet's* series on nutritional interventions in Ghana, geographical location and region are important determinants of child health and nutrition (Yawson et al., 2017). Just like the regional and rural-urban disparities in the prevalence of stunting, wasting and underweight, under-5 year mortality in 2014 ranged from 47/1,000 live births in Greater Accra to 111/1,000 live births in the Northern region (which is predominantly rural).

Child mortality rates in Ghana are stabilising, but malnutrition in children under-5 is still considerably high, and one of the major causes of death in children (Aheto et al., 2015b). There is a considerable amount of evidence in health literature suggesting that a child's nutritional status is correlated with a number of socioeconomic factors, including rural-urban residence, maternal education, and access to health care services (Novignon et al., 2015). Having difficulty in accessing health care services has been shown to be related to considerably higher levels of child malnutrition (Novignon et al., 2015). The aforementioned study, using evidence from the Ghana multiple indicator cluster survey found statistically significant differences in child malnutrition by place of residence (with rural areas counting for more than 70 per cent of malnourished children); mother's education (mothers with no education accounting for more than 60 per cent of malnourished children); wealth status (households with the lowest wealth quintile accounting for 53 per cent of malnourished children); and by region (with the Northern region accounting for more than 30 per cent and Greater Accra region less than 3 per cent) (Novignon et. al., 2015).

Several other studies show that rural-urban disparities interact with other variables such as poverty and maternal factors (like education), to influence child nutritional status and infant mortality rates (Quansah et al., 2016). In countries like Ghana, Senegal, Kenya, Benin and Cameroon, infant mortality rates were lower in urban areas (Wirth et al., 2006), suggesting that eliminating rural-urban disparities by increasing access to birth services and improving water and sanitation services in rural areas would help to improve child health status (Quansah et al., 2016).

Ewusie et al. (2017) investigated malnutrition in preschool children in Ghana across different geographic areas and socio-demographic groups, using the 2008 GDHS. The overall estimates of malnutrition were 35.6 per cent, which means 1.2 million children are stunted, wasted or underweight. The prevalence of all forms of malnutrition across ages by where they lived showed that both rural and urban areas have higher rates of stunting in children aged 1 and older than wasting or underweight. Urban areas reported stunting peaks for children 2 to 3 years (32.9 per cent); children aged 3 to 4 years old had the highest rate in the rural areas, which is almost 80 per cent more than the rates found in their urban peers. When analysing the prevalence by geographic region, the highest in stunting and underweight was found in the Upper East region (36.8 per cent and 27.3 per cent respectively); and the Northern region on the other hand, had the highest rate of wasting, with 13.8 per cent (Ewusie et al., 2017).

Inequalities in Sub-Saharan Africa

Evidence from 36 developing countries has shown that higher rates of stunting and underweight children relate to residence in rural areas (Smith et al., 2005). Fotso (2006) used multilevel modelling to analyse data from the DHS of 15 Sub-Saharan African countries, concluding that rural-urban differentials are substantially prevalent in all countries. Interestingly, they have comparatively narrowed in most countries, primarily because of an increase in urban malnutrition, and have widened in a few countries due to the fast fall in urban malnutrition (Fotso, 2007).

In the Sub-Saharan African context, rural-urban disparities are also evident. In terms of aggregates, about 78 per cent of stunted children in Sub-

Saharan Africa reside in rural areas. With regards to wasting, about 74 per cent of under-5 wasted children reside in rural areas, while 26 per cent are found in urban areas (see Appendix E). Again, the table shows that approximately 79 per cent of under-five underweight children in Sub-Saharan Africa reside in rural communities, while approximately 21 per cent reside in urban areas. Figure 5 presents the distribution of stunted children in rural and urban residences in Sub-Saharan Africa. The graph shows that with the exception of Gabon that has a little more stunted children in the urban areas compared to the rural areas, Sub-Saharan African countries have more stunted children in the rural areas compared to their urban areas. More striking is the rural-urban differences compared to the national average in countries like Burundi, Malawi, Ethiopia, Rwanda and Uganda. In Burundi, the national stunting prevalence is 55.3 per cent. However, 11.6 per cent of these stunted children live in urban communities, while 88.4 per cent reside in rural areas. The national prevalence for stunting in Malawi is 40.4 per cent, out of which 90.4 per cent reside in the rural areas and 9.6 per cent in the urban areas. In Ethiopia, the rural-urban ratio of stunted children is 89.8 per cent to 10.2 per cent respectively, against a national rate of 39.8 per cent.

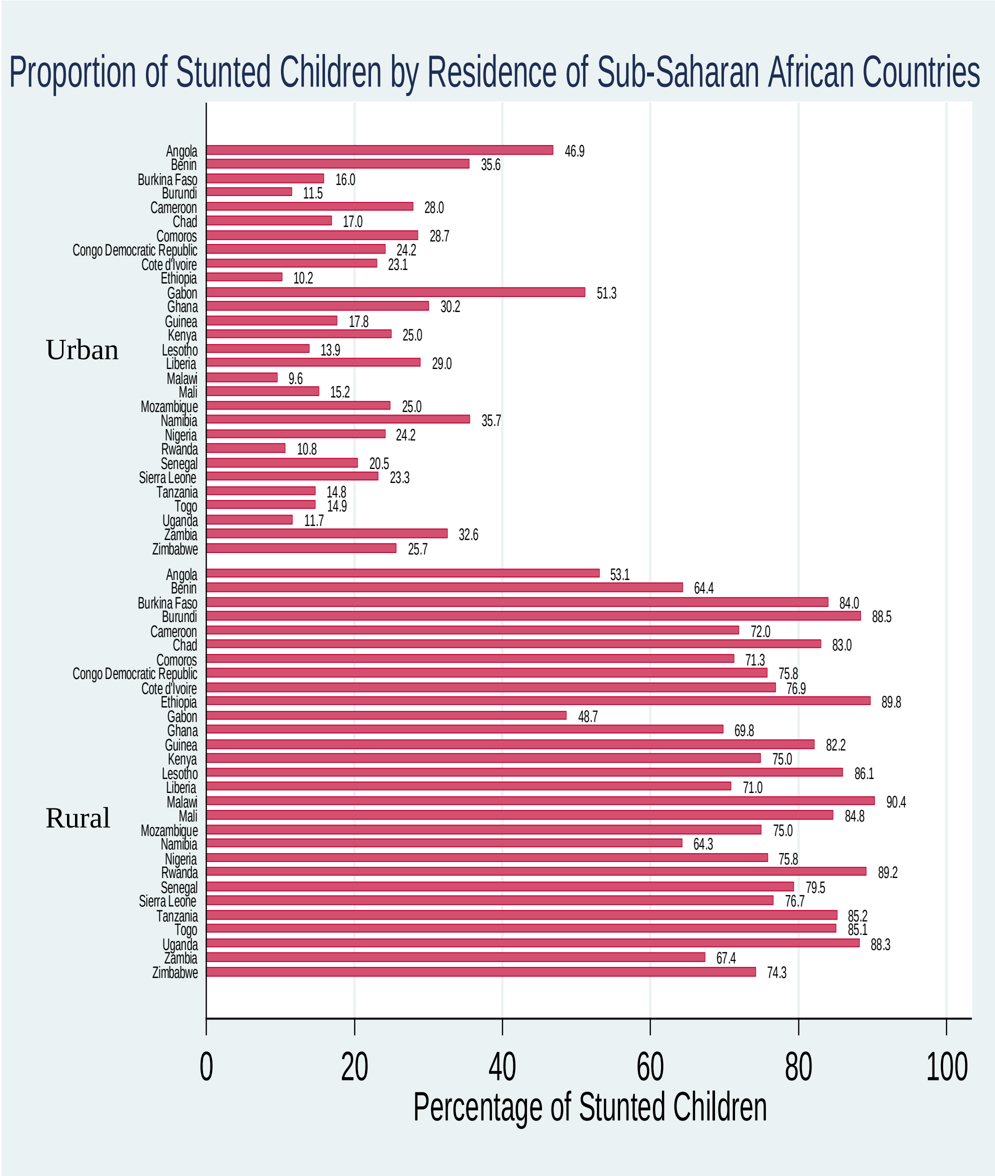


Figure 5: Distribution of stunted children by residence (urban-rural) of Sub-Saharan African countries as at 2016

Source: Agyen (2020)

In Rwanda, the rural-urban distribution of stunted children is 89.2 per cent and 10.8 per cent, respectively; the national prevalence is 40.8 per cent. Uganda recorded a similar rural-urban disparity: while the national stunting prevalence rate was 32.7 per cent, the country recorded about 88 per cent residing in the rural areas and approximately 12 per cent living in the urban areas.

With respect to wasting, only Angola and Gabon have a higher prevalence in the urban areas than in the rural (see Appendix F). Angola has a little more in urban than rural (51.5 per cent, urban; and 48.5 per cent rural). Gabon, on the other hand, recorded 60 per cent of wasted children from urban Gabon and 40 per cent from its rural residents. All other countries (including Ghana) recorded a higher rate of wasting in children in rural areas than urban areas. Appendix G also shows pertinent rural-urban disparities in the prevalence of underweight. Again, with the exception of Gabon, which shows a slightly high prevalence in urban areas (53.5 per cent compared to 46.5 per cent for rural), all the Sub-Saharan African countries recorded a higher prevalence of underweight in rural areas compared to urban areas. This shows the persistence of rural-urban disparities in under-5 children's nutritional outcomes in Sub-Saharan Africa. Just like the prevalence of stunting, huge rural-urban disparities were recorded in Burundi, Ethiopia, Malawi, Rwanda and Uganda.

It is worth noting that, based on these analyses, decreases in national malnutrition prevalence are not necessarily associated with declines or the absence of malnutrition inequalities across subpopulations within a country. This is consistent with findings from the WHO (2015) which state that – even in countries with very low overall prevalence of stunting – disparities are pronounced. This gives an indication of the significant contribution studies on stunting inequalities and other child health inequalities would make in the fight against malnutrition and poor health in children. The identification of vulnerable areas and area-specific factors is the first step in designing area-specific health-related policies and strategies to help narrow the gap and address health inequality problems.

CHAPTER THREE

LITERATURE REVIEW

Introduction

This chapter surveys and reviews theoretical and empirical literature related to the core issues in the current study. The chapter is divided into two main parts: theoretical review and empirical literature review. The theoretical review provides the basis of knowledge on child health, child health inequalities, the concept of place and its effect on health. This will help to establish the context for the current study within existing theory. The review of the empirical literature, on the other hand, looks at other related research studies and surveys that are based on actual observations and experiments.

Theoretical Review

This section examines the existing concepts and theories that underpin the context of this study. Four key theoretical issues are addressed in this section: (1) theoretical issues in the conceptualisation of health and health disparities; (2) conceptualisation of place; (3) theoretical conception of health and place (the concepts of social capital; proximity; the structuration theory; externalities); and (4) intersectionality theory and the determinants of health.

Conceptualisation of Health and Health Disparities

Health is key to economic progress since healthy individuals in society live longer and contribute immensely to productivity. This is why policymakers and public health practitioners attempt to improve general health for all devoid of geographical location, race or ethnicity, or other socioeconomic factors (Arcaya et al., 2015a). However, there exist differences in health among individuals by social group or geographical area. This section looks at the key concepts of health and health disparities and provides some theories underlying health disparities.

The Concept of Health

The concept of health dates as far back as the 5th century BC with Pindar's definition. Health, according to Pindar, is "harmonious functioning of the organs", considering the functionality of the physical body and the absence of pain. Around that time, several great Ancient Greek philosophers such as Plato, Aristotle, Democritus and Hippocrates made contributions to the concept of health that are relevant even today, and serve as the basis for overall health. In his *Dialogues*, Plato considered health to be the harmonization of the mind and body. While Aristotle based the concept on the social environment, Democritus linked health with behaviour, and Hippocrates explained health regarding environmental factors and way of life (Svalastog et al., 2017).

Today, health is not only considered as the absence of diseases but the capability of an individual to have a sense of self-acknowledgement and self-fulfilment which balances with human internal powers and potential outcomes with the sentiment of delight or disappointment while relating with the environment (Rutter, 1987). One globally accepted definition of health comes from the WHO. The definition which was part of the organization's constitution (signed in 1946 and adopted in 1948) states that, "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (*WHO Constitution*, 1948). With the recognition of the relationship between health and the social environment and living and working conditions, the WHO definition acknowledges social welfare as an essential constituent of health, in addition to physical and mental health.

With regard to child health, the National Research Council (US) and Institute of Medicine (US), define child health as " the extent to which individual children or groups of children are able or enabled to (a) develop and realize their potential, (b) satisfy their needs, and (c) develop the capacities that allow them to interact successfully with their biological, physical, and social environments." (2004, p.2) The concept of child health recognises that children are not capable of attaining optimal health alone. They rely on adults and the community to give them an environment in which they can learn and develop their potential effectively. This is partly why there is the need not just to observe an individual or a child's health differently, but also that of the community due to the interactions that take place there and our reliance on the social environment.

Health Inequalities and Health Inequities

The difference in the health status of individuals or distribution of health resources between different social groups of the population is called health inequality (Kawachi et al., 2002). In this case, the attributes of the differences are devoid of any moral judgement of unfairness.

However, health inequity is a form of health inequality, reflecting an unfair difference which is called health disparity. Thus, health inequity describes the differences that are systematically connected to being socially disadvantaged (an example, being of a particular race, socioeconomic status or religion) but could be avoided by reasonable means (Marmot et al., 2012).

Health inequities or disparities were first put on the map for public policy and academic study with the publication of 'The Black Report' in 1980, by the Department of Health and Social Security, now known as the Department of Health and Social Care in the United Kingdom (Gray, 1982). The report described an extreme inverse association between the social and economic situation (referred to as 'social class') with mortality from a wide range of diseases (Townsend et al., 1986). Despite the attention paid to this public health concern over the last 40 years, remarkable health inequities still exist between and within countries (Bartley, 2017). A vast body of evidence strongly links this to socioeconomic disadvantages which eventually leads to avoidable morbidity, disability, suffering, and premature death (WHO Commission on Social Determinants of Health, 2008). Furthermore, the degree to which socioeconomic factors impact on health has been shown to differ by locality, town, district, region, state, and even country (Mackenbach et al., 2008).

Ways of Operationalising the Concept of Health Inequalities and Health Inequities

There are different ways of dealing with health inequities between or within a population in a study. The standard way is to analyse the observation of health outcomes at group levels (Arcaya et al., 2015). The WHO indicates that "place of residence, race or ethnicity, occupation, gender, religion, education, socioeconomic status and social capital are relevant stratifiers that can be used to define the groups" (WHO, 2013). This approach is known as the group-level approach, and it is useful for identifying social inequalities in health.

Another approach is to concentrate on individual differences in health, depicting the variability of an operational measure over the population (Murray et al., 1999). This method has been used to study income across different countries, shedding light on the unequal distribution of resources around the world (Milanovic, 2010). Some critics argue that taking into account the general health of a population is beneficial since social groupings are defined differently and have varied meanings depending on country and place (Murray et al., 1999).

In research, there are different approaches to putting people into defined social groups. The composition of such groups could be based on membership (for example, ethnicity, "religion" or "race") though others are grouped based on "ordered" or "continuous" variable levels such as education or income. Although researchers need to make decisions about group definitions based on the research questions and hypothesis to be tested, clearly defined categories based on theory and supported by some contextual knowledge can facilitate health disparity examination (Arcaya et al., 2015).

Another theoretical issue to consider when studying health disparities is the dose-response versus threshold effects of variables (Arcaya et al., 2015). In this case, the focus is on the existence of a social gradient. A social gradient corresponds to a positive association between a social variable and the level or degree of health in a dose-response relationship (Marmot & McDowall, 1986). Here, increasing social resources (such as income) will correspond to an improvement in health levels. On the other hand, a threshold model is considered where the effect of the resource or variable exists or differs above or below a specific value (for example, poverty line).

Similarly, the differences in absolute versus relative measurement of variables is another critical issue to be considered by researchers for health disparity studies, especially those related to poverty (Sen, 1983). The absolute definition of the socioeconomic position has been dependant on a fixed monetary threshold (poverty line) specified by year and country. However, this approach ignores that societies can change the material needs for participation in society (Arcaya et al., 2015). For example, in recent times, access to phones, computers and cars have become factors for accessing work positions, education facilities, and health care. Social epidemiologists have offered some broad categories or potential reasons for health disparities across social groups and geographies. These explanations include material, psychosocial, behavioural and biomedical factors (Arcaya et al., 2015).

Another important consideration in the study of health inequality is the distinction between contextual and compositional effects on health. Compositional effects are the individual characteristics of people comprising a unit, while contextual refers to the influence of the place (unit) on individuals (Arcaya et al., 2015). Policies, infrastructure and support programs are key examples of contextual variables that impact health. Hence, they are targets for health interventions. The difference between the two effects is relevant when making inferences about how places impact health (Arcaya et al., 2015). In the following section, the conceptualisation of place or geographical location and its corresponding health inequalities are discussed.

Conceptualisation of Place (Neighbourhoods)

According to the first foundations of urban sociology by Park and Burgess in 1915, “a neighbourhood is a subsection of a larger community where a collection of people and institutions occupy a spatially defined area influenced by ecological, cultural and political forces" (Park, 1915). Communities were understood as areas that developed as a result of free-market competition, suggesting that communities are composed not only of a single unit but as a hierarchy of different residential groups (Suttles, 1972). Researchers have subsequently become interested in different strategies for defining neighbourhoods; for example, Grannis in 1998 critiqued the model as it is based only on geographical proximity without considering the logic of street patterns and social networks of neighbour interactions (Grannis, 1998).

In a more recent analysis of geography and health, there has been growing interest in the importance of distinguishing between space and place to explain the diverse means by which "geography" influences health (Arcaya et al., 2012). According to Arcaya, space considers proximity and measures of distance; for example, when considering the distribution of health risks and protective factors depending on the location. On the other hand, place indicates association to a political or administrative divisions, like states, cities and districts. The latter is important when contextualising health-related issues that are specific to these political and administrative units and their confines (Arcaya et al., 2015).

In a review of residential contextual effects, Sharkey and Faber (2014) suggested a flexible conception and measurement of neighbourhood. In the review, it was emphasised that there is no unique definition of neighbourhood and no specific operationalization of the concept that is sufficient to capture the ways in which residential and place context influence the lives of its residents (Sharkey & Faber, 2014). Studies require scales that are more specific to the types of interactions being studied. Sharkey and Faber argue that, instead of seeking for a fixed definition of neighbourhood and how to measure it, the broader focus should be on the social process that operates within residential settings and the consequences for the individual, depending on the research questions (Sharkey & Faber, 2014). In brief, the fundamental construct of neighbourhood is the idea of place as a system of resources relevant to health and social relationships that are within the geographical borders (Curtis & Rees Jones, 1998).

Theoretical Conception of Health and Place

Differences in inherent biological factors, including differences in hereditary susceptibilities across populations, may influence explicit health inequalities. However, where inequalities in health exhibit a structured pattern across geographical areas or socio-demographic factors, in most cases they are determined by social disparities or social arrangements, policies and practices than make certain groups more liable to certain health conditions than others (Rose, 2001). As discussed in the previous sections, the efforts to understand the underlying association between health and place on such structured health inequalities has led to compositional and contextual explanations. The compositional explanation considers shared characteristics of residents and the contextual which has got to do with the existence of ecological attributes like pollution that affects everyone in a geographically defined area. However, it has been argued that this conceptualisation may be an oversimplification (Bernard et al., 2007a). As De Koninck & Pampalon point out, distribution of residences is neither random or totally intentional. It is influenced by decisions or the absence of them and shaped by an interconnection between economic means, lifestyles, neighbourhood characteristics, resources, services, quality of housing, reputation, history and social relationships (De Koninck & Pampalon, 2007).

Bernard et al., (2007) gave a detailed explanation of a conceptual framework of the effects of neighbourhoods on health. The main approach to understanding this relationship in their framework is through differences in the distribution of resources. Their conceptualisation of neighbourhood has five domains through which people may or may not acquire the resources needed for producing and maintaining good health in daily life.

Conceptual Framework for Studying Health Disparities and Place

As stipulated by Bernard et al. (2007b) health inequalities can be determined in relation to the accessibility of resources by individuals or social groups. The authors argue that neighbourhoods may provide resources with positive effects like quality schools, quality health centres and a neighbourhood-watch committee; and others with adverse effects like pollution and violence. These resources are not equally relevant for different population groups, but they can play an important role. Bernard et al. (2007) consider two different environments. First is the physical domain as 'the nature of its different components and by the rule of proximity'. It includes natural resources such as air, climate and soil, and built resources; for example, the quality of housing, presence of graffiti and parks. The other, social environment comprises of four domains: economic, institutional, community organization, and local sociability domain.

Social Capital

Social capital, as defined by Coleman (1994), is a set of socio-structural resources that make up some part of the social structure and aid the activities of individuals in that structure. It looks at the resources that are accessible to individuals due to their membership of a particular network. Social capital constitutes the ecologic characteristic of the social structure, including the individual, also known as the ego-centred and the collective or socio-centred perspective (Álvarez & Romaní, 2017).

In their study on insights into measuring social capital, Álvarez & Romaní (2017) highlighted the need for a comprehensive pathway through which the varying resources and network characteristics affect individual and collective health. Their study discussed in detail the two main schools of thought: social cohesion and social networks in the study of social capital in public health. Social cohesion describes the solidarity within groups and the willingness of the members to cooperate as a result of a strong social bond. Social networks, also called social support, maps relevant relationships between individual actors within a specific network. Álvarez and Romaní describe four major pathways through which social capital at the neighbourhood level has a contextual effect on individual health and well-being; (1) the diffusion or dissemination of information on health-related issues, (2) the sustainment of health-related norms by informal control, (3) the accessibility of local services and amenities and, (4) the psychosocial processes that provide mutual support. It is therefore essential to take into account all these mechanisms while identifying the specifics relevant for the exact context in which the research is conducted.

Islam et al. (2008) classified social capital indicators into two categories: proximal and distal. They view the proximal indicators as outcomes of social capital constituting trust, networks and reciprocity, while distal indicators are those linked indirectly with its major component. They remarked that a unique feature of social capital is its complexity feedback effects. According to the Productivity Commission (2003), the complex feedback effect generally occurs between its sources or causes and its effect which results in 'virtuous cycles' of social capital creation. For instance, education is seen as a fundamental attribute of social capital at the individual level. Likewise, access to social capital may provide educational prospects for individuals and their children. The commission emphasises that society can benefit from social capital through (1) reducing transaction costs, (2) facilitating the dissemination of knowledge, information and innovation (3) promoting cooperative and socially-minded behaviour to prevent self-interest which provides no good for the society, and (4) through individual benefits and associated social spillovers.

Proximity

With reference to Bernard et al. (2007), the pathway through which neighbourhoods could affect health is accessibility and proximity influenced by the social environment. The literature indicates that the effect depends on how close individuals are to resources mediated by the interplay of economic forces, institutional arrangements, and relations of informal reciprocity. The quality and availability of resources such as quality schools, health centres, and good drinking water have been associated with health and health experiences or behaviours of individuals. For instance, van Lenthe et al.

(2005) have shown how in the Netherlands residents of socioeconomically disadvantaged neighbourhoods almost never engage in sports activities, depicting an association between neighbourhood characteristics and physical inactivity. LaVela et al. (2004) also indicate that, in the United States of America, veterans with spinal cord injuries and disorders (SCI&D) visit a Department of Veterans Affairs health care facility less frequently to check their health when such facilities are farther away from their residence. Evidence from New York City also shows that fire protection, sanitation and disinvestment in municipal services in neighbourhoods affects the health and safety of individuals in the neighbourhood.

Bernard et al. (2007) assert that resources, which should be made available universally and equally accessible through institutional domain to all members of the society according to their needs in an equitable society is in fact not applicable in practice. They attribute this to a lapse in political judgement and the imposition of opinions about the needs of people, leading to unequal distribution of facilities and the enforcement of rules of access to these facilities.

Structuration Theory

The role of neighbourhoods in determining the health outcomes of their residents has become an area of interest in recent years. British sociologist Anthony Giddens (1984) proposed a delicate recursive relationship between structure and agency, in which structure refers to rules and resources upon which action and interaction can be built, while agency depicts internal motivations in society. In his theory of structuration, Giddens propounded multilevel explanations on the relationships between structures and human experiences in explaining the health inequalities seen in an area of residence. The role of structure, to him, could be both a constraining and an enabling element for human action (Giddens, 1984).

As with any theoretical issue, the theory of structuration has two main components; ontology and epistemology. Ontology connotes the existence of some phenomenon, while epistemology emphasises the philosophical theory of knowledge, recognising both its sources and limits (Cloke et al., 1991). Giddens sought to prove the existence of a balance between structure and agency: termed the 'duality of structures' with an emphasis on the balance human actors play with their limited choices. The theory postulates that people do not have the entire preference of their actions and, with restricted knowledge, even so, they are the same elements that recreate the social structure. In essence, structure and agency become united in human practices (Craib, 1992).

Applied to health, the theory of structuration suggests that the health practices of a group of people are as important as the absence or presence of health facilities in explaining their health outcomes. This is to suggest that the poor health outcomes of a given population can be accounted for by the balance between the society's structure by means of accepted norms and values. The theory of structuration has been incorporated in medical sociology and public health as a theoretical framework for bringing social theory into health research, especially in understanding health inequalities in population sub-groups and between different towns and cities (Bernard et al., 2007b; Choby & Clark, 2014; Williams, 2003). In the study, the structuration theory constitutes the key underlying theory.

Externalities and Health

The decisions and interactions of individuals residing in a given society may directly or indirectly affect others through market and non-market activities (Islam et al., 2008). This effect on a third party, whether negative or positive, is termed externality. The concept of externality has been predominantly used in economics (Lucas, 1988; Marshall, 1890). As noted above, social capital has been regarded as one of the significant factors of health inequality (Álvarez & Romaní, 2017; Coleman, 1994). There is, however, debate concerning the mechanism through which social capital could yield benefits or be detrimental to an individual. After Coleman (1994), Glaeser et al. (2002) showed that social capital is a community characteristic which develops from social interactions (rather than an individual characteristic) while Anderson et al. (2004) showed that social capital has an individual and community dimension. Social capital as a community attribute, considers all cross-person externalities consisting of the individual social capital produced in a society or community (Glaeser et al., 2002; Islam et al., 2008).

Intersectionality Theory

The past few decades have witnessed the importance of overlapping and intersecting identities and factors that affect an individual in research. This approach, known as the intersectionality approach, is a body of normative theory and empirical research which considers interconnections and interdependencies between social categories and systems (Hancock, 2007b). While the works of Truth (1851) conceptualise the notion of intersectionality, the theory of intersectionality has predominantly been attributed to Crenshaw

(1989). Crenshaw's work was a critique of anti-discrimination laws which considered gender and race separately and consequently left African-American women and women of colour without justice.

Since its introduction, the approach has been adopted by many disciplines, including sociology, business, political science and health, and argues for the need move away from viewing social factors as mutually exclusive categories to a causal complexity that emphasises on the existence of multiple paths to the same outcome (Hancock, 2007a). According to (Hancock, 2007b), the concept of intersectionality is premised on six main assumptions: (1) the existence of multiple categories of difference; (2) the multiple categories of difference are not mutually independent variables which can be added together to comprehensively examine and answer a research question; (3) the categories of difference constitutes the makeup of individual and institutional factors and are simultaneously contested and enforced at the individual and institutional levels; (4) each category of difference has within-group diversity; (5) the examination of categories at multiple levels; and (6) the intersectionality concept as a normative and empirical paradigm demands both empirical and theoretical backing.

In research, intersectional approaches significantly vary, from unitary and multiple approaches (Hancock, 2007b). While one variable of interest from a social position is considered in a unitary approach, the multiple approach, although takes into account several social categories or variables, regards numerous marginalisations or benefits as individual classifications that can be layered under an additive assumption (Hancock, 2007b). Conversely, the intersectional approach presumes that a person's exposure, health and well-being, are not just achieved by adding together their various parts, but rather may be comprehended in a more prominent multifaceted nature through intercategorical ways to deal with intersectionality (McCall, 2005). The effect of gender on health, for example, may be established through cultural meanings and social processes, which may be negative or positive.

Intersectionality of the Determinants of Health

According to Bowleg (2012), intersectionality is considered a substantive theoretical framework for public health. With its primary tenet that social categories such as race, socioeconomic status and gender are multiple, interdependent and mutually constitutive, but not independent and unidimensional, Bowleg advocated for a more noteworthy attention to intersectionality in public health. He affirmed that intersectionality provides a theoretical framework for more directive public health theory, research and policy.

The theory has not only been used in feminist research, it has been explicitly incorporated in health research too, and mostly within qualitative studies. For more than two decades, the theory has received recognition for its ability to explain health inequalities through varying instituted social factors of health and determinants of health inequalities (Bauer, 2014; Hankivsky et al., 2017; Hankivsky & Christoffersen, 2008; Kapilashrami & Hankivsky, 2018; Kelly, 2009; Nygren & Olofsson, 2014). Although studies on specific biological and social determinants of health have proven to be very important, they often neglect the provision of practical evidence that directs population or local-level strategic policy interventions within the geographic and socioeconomic context. Unlike such unitary and multiple approaches, intersectionality provides specific intersectional associations of varying factors of health (Bauer, 2014).

Due to the implicit complexity and multiplicity characteristic of intersectionality, it is quite challenging and daunting to carry out such research quantitatively (Bowleg, 2012; McCall, 2005). As outlined by Bowleg (2012), it is even more challenging to fully incorporate the theory in population health research fully. Bauer (2014) presented seven main challenges and possible solutions to better explain health inequalities. Among these is the lack of well-defined methodology for incorporating intersectionality in quantitative health research. Several studies have proposed statistical methods including hierarchical class analysis (Stirratt et al., 2008), multilevel modelling (Black & Veenstra, 2011) and latent class analysis (Garnett et al., 2014). Bauer (2014) proposed that, there is a need for a disaggregated terminology to avoid mixing similar concepts and provide a clearer understanding.

Review of Empirical Literature

This section reviews the extant literature on child health and the effects of neighbourhood characteristics. The focus of this empirical review is on four main subjects related to the three empirical chapters: spatial variations and child health; modelling and measurement of place or neighbourhood effects; role of mothers' education on child health and empirical issues on the effect of improved water on child health.

Spatial Variations and Child Health

The extant studies that have been conducted on child health have been in relation to demographic, maternal and social factors at the individual level.

However, much has not been unveiled in regard to the relationship between spatial determinants and child health. This section reviews literature that identifies the relevance of spatial influences in child health through an analysis of spatial variations of child health studies conducted in different countries; from a global perspective to Sub-Saharan Africa and finally, look at the Ghanaian context.

From a global perspective, conventional spatial variation analysis on child health have been conducted by studies (Burstein et al., 2019; Lim et al., 2012; Reiner et al., 2020). Reiner et al. (2020) employed Bayesian model-based geostatistics to estimate geographical inequalities in the burden of under-5 diarrhoea in low and middle-income countries (LMICs). They used data from 466 surveys in 94 LMICs and found substantial variation within countries with most of the burden of diarrhoea and the highest mortality risk from Sub-Saharan Africa and South Asia. Their results also indicated the persistence of geographical inequality in countries, including those with relatively low burdens of diarrhoea. Burstein et al. (2019) also analysed and quantified spatial variations in neonatal, infant and child deaths using geostatistical survival models and data from 99 LMICs. The study identified high mortality clusters and patterns of geographical inequalities within these countries. Lim et al. (2012) estimated exposure distributions of the risk factors of childhood communicable diseases. The authors found that the biggest risk factors in most Sub-Saharan African countries are childhood underweight, household air pollution from solid fuels, discontinued breastfeeding and non-exclusive breastfeeding. Though these three studies are commendable for clarifying some geographical inequality concerns with huge datasets, it appears that the aim of these studies was focused on quantifying geographical inequalities rather than the analysis of the inevitable role of geographical locations. For example, Lim et al. (2012) failed to explore the possibility of the effect of household air pollution from solid fuels on members of other households in close proximity.

Khan and Mohanty (2018) used univariate and bivariate local indicator of spatial association (LISA) maps, spatial lag and spatial error models, and found that malnutrition (stunting, wasting and underweight) is spatially clustered across the districts of India. The authors found that a substantial number of districts from poorer states in India have high prevalence a of stunting and underweight.

A study by Kandala et al. (2011) on spatial variations in under-5 malnutrition showed significant geographical differences in the Democratic Republic of Congo (DRC). This study used a geo-additive semiparametric mixed model based on the Markov Chain Monte Carlo techniques. It was argued that childhood malnutrition is spatially structured, with the most vulnerable children located in the poorest households in rural areas.

Gayawan et al. (2017) used Bayesian semiparametric quantile regression to investigate the geographic patterns of malnutrition among Nigerian children under the age of five. The study observed geographic patterns of child health at the state and local government levels. The results from this study show striking malnutrition (stunting, wasting and underweight) variations at the state and local government level in Nigeria. The authors observed higher stunting rates in the northern parts of Nigeria, and pockets of higher rates of both stunting and wasting in some states in the south. However, the study could not account for the variations across geographical locations and speculated that it could be explained by the diversity in sociocultural and ethnic structure in Nigeria.

In the Ghanaian context, Aheto et al. (2015) investigated the geographical variations of malnutrition in under-5s across Ghana. The study used a random intercept multilevel regression model to examine the risk factors of malnutrition. The focus, however, was on the examination of household-level differences in childhood nutritional outcomes (weight-for-age, height-for-age and weight-for-height ratios). The study found that malnutrition varies significantly across households in Ghana, giving an indication of geographical differences in the factors that drive malnutrition in Ghana. Although the study presented commendable findings, it was unable to identify specific administrative areas and policy variables to help target interventions. The authors therefore suggested the need for the identification of risk factors of malnutrition that account for the variations observed.

Aheto et al. (2017) also aimed at modelling and forecasting spatial variations of malnutrition in under-5s in Ghana with data for the 1993, 1998, 2003 and 2008 GDHS. The authors used individual-level covariate data from the four survey years to present individual-level variability with the assumption of a homogeneous distribution of observations over space. The study found substantial spatial variations in chronic malnutrition (stunting) across Ghana, with higher prevalence in some parts of northern Ghana and the Western region. However, the assumption of homogeneity of space is practically not optimal because of the presence of geological predisposition

(Floch & Marcon, 2018) as a result of combining several survey years in the same space. This may lead to biased estimates and predictions.

In Ghana, though there are quite a lot of studies on child health and its social and demographic correlates, these have been at the individual and household level. Very little is known about the spatial variation of child health – especially stunting across districts.

Modelling and Measurement of Place, Area or Neighbourhood Effects

Neighbourhood Effects and Measurement of Place

Recent years have seen a growing interest in the effect of neighbourhood or area characteristics on individual health outcomes. The relationship, mainly considered between place of residence and health, beyond individual-level risk factors, has been observed for a variety of health outcomes including child nutrition (Liu et al., 2015), tobacco consumption and smoking initiation, adolescent risk behaviours (Tam & Freisthler, 2015), obesity (Hoyt et al., 2014), cardiovascular diseases (Costache et al., 2015), lung and colorectal cancer (Hines et al., 2014; Johnson et al., 2014), infectious diseases (Ford & Browning, 2014), child mortality (Adekanmbi, 2015), general mortality and other health problems in a wide range of countries (Abdul-Sattar & Abou El Magd, 2017). A major subject of concern for the execution of these studies is how to measure place or neighbourhood effect.

Two main measures of neighbourhoods are the supposed 'objective' and 'perceived' measures. The objective measure assumes distinct features of the social and physical environment, such as prevalence of vices and availability amenities/services in a defined area (district, census tracts) (O'Campo & O'Brien Caughy, 2006). According to empirical evidence, the objective measure provides more conclusive phenomena relating to health outcomes which informs policy and intervention (Yakubovich et al., 2020). However, it is argued that the neighbourhood environment captured through this measure does not reflect experiential context, which forms part of the neighbourhood effects (Cummins et al., 2007a; O'Campo & O'Brien Caughy, 2006; Sampson et al., 2002). The objective measure's concept of neighbourhoods seldomly represents individuals' own conceptions and experience of neighbourhoods (Basta et al., 2010; Chaix et al., 2012; Diez Roux, 2001; Sampson et al., 2002). Perceived measures of neighbourhoods, on the other hand, allow for individuals to report on how they conceive or experience the physical component of their neighbourhoods. The challenge here is that the perceived measures are virtually impossible to use in a secondary data analysis, for example planning for interventions based on individuals' perceptions of a particular area (Basta et al., 2010; Chaix et al., 2012; Haynes et al., 2007). The perceived measures of neighbourhoods may, therefore fail to capture aggregated confounding effects of neighbourhoods (Chum et al., 2019; Sampson et al., 2002).

The pathways for both the objective and perceived measures of neighbourhood are reasoned to vary over time. However, the extent of variation is contingent on social factors at the individual level and the point in time of measurement (Yakubovich et al., 2020). Both measures with respect to accessibility also indicate proximity to amenities and community services or facilities though the objective measure gives more substantial indication of accessibility to the facilities than the subjective or perceived measure (Nyunt et al., 2015).

Sampson et al. (2002) assessed and synthesized the cumulative results of the literature on neighbourhood effects, examining the social processes related to health outcomes. They found that studies in this area included three categories:

1. Neighbourhood-level studies with neighbourhood-process measures where the dependent and independent variables are expressed as aggregate scales, counts, or rates across ecologically defined areas,
2. Multilevel studies with neighbourhood-process measures, in which sample participants are within a defined neighbourhood, the dependent variable is measured at the individual level, and the independent variables include both individual-level factors and aggregate-level measures of neighbourhood characteristics (both structure and process),
3. Multilevel studies with proxy neighbourhood-process measures, identical to the last category but with social processes measured at the individual level.

One of the most important findings in these studies is the confirmation that community-based surveys can generate reliable measures of social and institutional processes within a neighbourhood. However, the methodology needed to evaluate these measurements wasn't widespread at the time. Hence, Raudenbush and Sampson (1999b) suggested moving toward a 'science of ecological assessment' called 'ecometrics.' The authors suggested the development of systematic procedures for directly measuring neighbourhood mechanisms which could be treated as ecological. Examining the multitude of operational definitions, the empirical findings and theoretical orientations, they came up with four classes of neighbourhood mechanisms: 1) social ties and interactions; 2) norms and collective efficacy; 3) institutional resources (quality, quantity and diversity of institutions in the community); and 4) routine activities (Sampson et al., 2002).

Despite the progress, there are still methodologically complex challenges in measuring neighbourhood effects. The differentiation of an individual into units, the indirect pathways of neighbourhood effects, and bias still present difficulties for researchers. For example, the most used strategy in the multilevel research is to estimate a direct effect model, taking individual variables as controls along with place-of-residence characteristics; however, this model may be partitioning out relevant variance and pathways of influence (Sampson et al., 2002). As suggested by Cook et al. (1997), the universal use of the phrase ‘neighbourhood effects’ can be problematic for the methodological point of view and should be analysed with care, since neighbourhoods may be internally heterogeneous and not as uniform as may be perceived.

Sampson et al. (2002) provide five directions for designing research on neighbourhood contexts where they are considered as social processes (thus, as ecometrics): (1) redefining neighbourhood boundaries in the context of social interactions, (2) collecting data on the neighbourhood’ physical and social properties, (3) considering the spatial interdependence between neighbourhoods, (4) analysing the neighbourhood social processes and how they change in time, and (5) collecting scale data on neighbourhood social processes.

Role of Mothers' Education on Child Health

Mothers' education has gained considerable attention over the years among the potential social attributes of child health due to its policy implication attributes. Although empirically there is a modest contention among researchers on the effect of mothers' education and child health regarding the appropriate level of education, there is a consensus from the theoretical perspective on the effect of mothers' education on child health. Most studies on mothers' education restrict the scope of the importance of mothers' education to individual mothers and their offspring. Drawing on empirical studies, this section reviews the pathways through which maternal education may affect child health.

A major pathway through which a mother's education may affect child health is through socioeconomic factors (Alemayehu Azeze & Huang, 2014; Frost et al., 2005; Grépin & Bharadwaj, 2015; Keats, 2018). Evidence from Zimbabwe suggests that increased education levels lead to improved economic opportunities for women (Grépin & Bharadwaj, 2015). Keats (2018) found that women who are more educated are likely to get better jobs and increase household wealth. It is also evident that, uneducated people, often find jobs in the informal sector, while people with more education are placed in the formal sector and earn higher incomes (El Badaoui & Rebiere, 2013).

In line with the channel relating to socioeconomic status, education may promote empowerment and autonomy (Jejeboy, 1992). Education has been proven to afford women relatively better positions in the household (Thomas, 1990). Behrman (2015) indicated that education enhances women's abilities to participate in decision making processes.

Other studies (Basu & Stephenson, 2005; Desai & Alva, 1998) have identified personal illness control and attitude towards healthcare as the pathway. Basu and Stephenson (2005) argue that maternal education significantly affects healthcare-related behaviours, such as seeking and receiving prenatal care through pregnancy and seeking medical care for the treatment of a child's fever or cough. Evidence from Uganda also shows that children are more likely to receive immunization shots and vitamin A supplements to support healthy immune systems and prevent blindness (Desai & Alva, 1998; Keats, 2018). Prickett and Augustine (2016) found that higher levels of maternal education are related to more beneficial health investment behaviours at each phase of the early development of a child, thereby improving health and well-being of the child.

Another pathway through which maternal education can affect child health is the adoption of modern attitudes and practices towards health. As outlined by Andriano and Monden (2019), education facilitates the acceptance of rational explanations of illness and the adoption of modern medical treatments and practices. Women who are educated, therefore, are more likely to find effective health care for treatment of diseases for their children (Basu & Stephenson, 2005; Glewwe, 1999). Evidence from Bolivia shows that education reduces the usage of some traditional and harmful curative practices, such as withholding fluids during diarrhoea (Bicego & Boerma, 1990).

Glewwe (1999) asserted that formal education confers health knowledge on future mothers in addition to acquiring skills in diagnosing and treating some common child-related diseases and being more receptive to modern medicine. Education thus improve mothers' health knowledge on the use and effectiveness of contraceptives (Rosenzweig & Schultz, 1989), how HIV spreads and its preventive measures (Agüero & Bharadwaj, 2014) and the most appropriate prenatal practices (Basu & Stephenson, 2005; Grossman, 1972). In Ghana, Frempong and Annim (2017) found that mothers who have at least primary education are more likely to feed their children with a diversified diet that improves their health compared to those with no education.

Another way that maternal education might influence child health outcomes is through environmental variables (Andriano & Monden, 2019; Emina et al., 2009). The authors argued that educated women tend to live in more environmentally clean areas. Such women are mindful of the implication of poor sanitation and hygiene practices and are therefore successful at mitigating the incidence of diseases such as diarrhoea (Andriano & Monden, 2019; Hatt & Waters, 2006; Hobcraft, 1993). Desai and Alva (1998) indicated that women with higher educational attainments purposefully choose to live in communities with improved amenities and good medical facilities.

Chen and Li (2009) examined whether the maternal education effect on a child is a nurturing effect. The authors found that, compared to their own children, the effect of a mother's education on adopted children (who are genetically unrelated to the mother) show no differential effect, suggesting that a mother's education has mostly post-natal nurturing effect on child health.

Premised on these substantive pathways and arguments, several studies from Ghana (Addai, 2000; Benefo & Schultz, 1996; Greenaway et al., 2012;

Kanmiki et al., 2014; Nakamura et al., 2011), Sub-Saharan Africa (Caldwell & McDonald, 1982; Casale et al., 2018; Fadare et al., 2019; Yaya et al., 2019) and other parts of the world (Emamian et al., 2014; Garcia et al., 2013; Stamenkovic et al., 2016) also found a significant effect of mother's education on child health. However, these studies only considered the effect of an individual mother's education on their offspring – overlooking the salience of social capital and externalities that may broaden the effect of mother's education on other children in close geographic proximity through the sharing of health-related knowledge with other mothers and copycatting of good health behaviours and practices by other mothers.

Other (Non-Health) Effects of Neighbouring Mothers' Education

Other research has looked at the impact of neighbouring mothers' schooling on children who live in close geographic proximity that are not necessarily related to health. Kamanda et al. (2016) found that higher education attainment of mothers within a community increases the secondary school attendance of children in that community regardless of the child's own mother's education. The authors also found that an increase in mothers' education in a household enhances primary school attendance.

Poor Neighbourhoods and Child Health

Empirical evidence has shown that residential neighbourhoods influence their sense of well-being (Ludwig et al., 2012). Sampson (2012) and Ludwig et al. (2012) described a randomised housing mobility experiment, 'Moving to Opportunity' carried out in five different cities in the United States in the mid-1990s. The experiment was said to have given housing vouchers to some residents of poor neighbourhoods, only to be used to move to less poor neighbourhoods. The authors 10 to 15 years later used this data and found that after controlling for income, the group of individuals who moved experienced significant improvements in their well-being compared to those who didn't. This corroborated Aber et al. (1997), who argued that a middle-income family's wealth may mean little or may have little influence if that family is 'trapped' in a poor community. They further argued that such households would be exposed to the same environmental risk and use the same medical services as their poor neighbours. Such neighbourhood effects ultimately affect a child's health outcomes.

In Ghana, Annim et al. (2012) found that spatial inequality is significant on household poverty at the district level. The authors indicated that the signs of the effect differ based on the economic activities of the particular district. This suggests a varying and significant effect of location on household poverty which is an important determinant of child health.

Empirical Issues of the Impact of Improved Water on Child Health

Over a decade, several studies have shown the importance of improved water on child health (Dangour et al., 2013; Fink et al., 2011; Taylor et al., 2015). For most of these studies, improved water sources are positively associated with child health. Other empirical studies on the other hand, have underscored differing results (Bain et al., 2012; Godfrey et al., 2011; Headey & Palloni, 2019; Shaheed et al., 2014).

The impact of improved water on child health however is likely to be mediated by the neighbourhood or place of residence, since some areas although might have improved water sources may not have associated microbial safety (Shaheed et al., 2014). For some areas or communities, the water available might not be enough (in terms of quantity) for sufficient basic health needs; it also might not be affordable or be guaranteed as safe for use. This could explain the inconsistencies in the results regarding improved water and child health.

Dangour et al. (2013) conducted a meta-analysis at the study and individual-level to evaluate the effect of interventions to improved water among other factors on the nutritional status of children. The study found a statistically significant effect of improved water on height-for-age z-scores, but indicated that none of the 14 studies reviewed reported on differential impacts such as socioeconomic differences which are relevant to the issues of inequality. This was corroborated by Taylor et al. (2015), who also conducted a systematic literature review to investigate the impact of WASH interventions on malaria control. They acknowledged the distinct gap in literature and reiterated the need for the most appropriate intervention for a given context and/or target group.

Fink et al. (2011) noted that improved water is contributes to better child health, but that the effect is relatively small. This study used data from 171 surveys of the DHS from LMIC for the period 1986 to 2007. They used logistic models to examine the effect of access to water and sanitation on infant and child stunting, diarrhoea and mortality. The use of this model ignores the possibility of environmental attributes (like water shortages and pollution) that affects groups of the population, resulting in similar characteristics among individuals in these groups. This situation therefore violates the assumption of independence of observations and may lead to biased parameter estimates and false indications of significance.

Headey and Palloni (2019) used a large, subnational panel on difference-in-difference regression models to examine the effect of long-term changes in access to water on child health (morbidity, nutrition and mortality). They constructed a panel of 442 subnational regions from multiple rounds of the DHSs of 59 countries. Their results showed that access to improved water does not significantly affect most health outcomes. The study, however, employed fixed-effects models that consider systematic effects as fixed or non-random. This approach falsely assumes that the effect of access to improved water is the same across different neighbourhoods or locations.

A 2012 study on a comparative assessment of burden of diseases by the authors of *The Lancet*’s Global Burden of Disease series (Lim et al., 2012) found that access to an on-plot pipe water supply does not significantly reduce an individual’s risk to diseases. The study investigated the effect of water and sanitation interventions on the risk of diarrhoeal diseases by conducting a review of experimental and quasi-experimental epidemiological studies. The authors further found that the magnitude of the effect of improved water on communicable diseases in children has changed substantially and varies across regions. Subsequently, Engell and Lim (2013) followed up with a reanalysis of the experimental and quasi-experimental studies and discovered that both unimproved water and sanitation account for only 0.9 per cent of the global burden of disease in 2010, compared to 6.8 per cent in 1990 and 3.7 per cent in 2000. They again indicated that there are no additional effects of on-plot water or piped water on health compared with other water supply improvement. Consequently, Shaheed et al. (2014) argued that not all improved water sources – including piped water – are safe, since they are susceptible to contamination. They further argued that some sources of piped water (for example) may be untreated or unsafe. Some households may need to store their water once collected, due to intermittent supply and therefore may be easily contaminated. That is to say that, availability or access to improved water sources is not a guarantee of consistent use of these same sources over sustained periods.

Review of the Other Determinants of Child Health

This section briefly reviews the determinants of child health (stunting) and the relationship between variables.

Sex of Child

Several empirical studies suggest that male children are more likely to have ill health – especially stunting than female children. These studies on the relationship between gender and child health are accessible in the case of Sub-Saharan Africa (Bork & Diallo, 2017; Espo et al., 2002; Ngare & Muttunga, 1999; Ukwuani & Suchindran, 2003; Wamani et al., 2004, 2007; Zere & McIntyre, 2003) and Ghana (Darteh et al., 2014; Frempong & Annim, 2017). Although some studies attribute the differences in child health with respect to gender to behavioural factors (Garenne, 2003) and dietary discrimination (Leslie et al., 1997), Cronk, (1989) and Wamani et al. (2007) contest these assertions and suggest biological explanations. In neonatology, epidemiological studies also show that male children suffer higher morbidity and mortality when compared to females, even after adjusting for gestational age and size of the child. These studies, carried out on cohorts of preterm infants and children, attribute gender-related differences to sex-chromosome factors that are associated in preterms and linked to ventilator and circulatory support (Elsmén et al., 2004; Kilbride & Daily, 1998; Synnes et al., 1994). These studies generally suggest that boys are more vulnerable than girls.

Age of Child

According to Darteh et al. (2014), the age of a child influences the child's susceptibility to being stunted. They further argued that children 24 months and above are more likely to be stunted compared to those younger than 24 months. According to the Noguchi Memorial Institute for Medical Research (as cited in Darteh et al., 2014) this could be attributed to complementary feeding, which starts for most children between 4 months and 6 months. Some studies have also shown that the period of complementary feeding is critical for child health because of the higher occurrence of micronutrient deficiencies associated with this period (Higgins et al., 2011; Qasem et al., 2015; Shrimpton et al., 2001). These studies and several others in developing countries give the indication that the risk of stunting significantly increases with age (Kang et al., 2018).

Size at Birth

An important factor that has been said to influence stunting in infants and children is the child's weight or size at birth (Christian et al., 2013; Espo et al., 2002; Kroupina et al., 2015; Pedraza & de Menezes, 2014; Rehman et al., 2009). Singh et al. (2017) found that children with an average or large birth size are less likely to be stunted than their counterparts who were smaller in size at birth.

Mother's Age

Research shows that maternal age is a critical factor that affects child health. Empirical works on the relationship between maternal age and child health indicate that younger mothers at childbirth (below 20 years) are more likely to experience intrauterine growth restriction, preterm births, child malnutrition and infant mortality (Alam, 2000; Borja & Adair, 2003; Conde-Agudelo et al., 2005; DuPlessis et al., 1997; Fall et al., 2015; Gibbs et al., 2012; Lawlor et al., 2011; LeGrand & Mbacké, 1993; Markovitz et al., 2005; Paranjothy et al., 2009; Restrepo-Méndez et al., 2011; Sharma et al., 2008). These are explained by biological, social and behavioural factors. Younger mothers' nutritional needs may compete with their foetuses during pregnancy if these mothers are still growing, which ultimately affects foetus development (Scholl & Hediger, 1993). LeGrand and Mbacké, (1993), and Wambach and Cole (2000) indicate that younger mothers might breastfeed for a shorter duration compared to older mothers. They also argued that younger mothers may have an immature demeanour and consequently may not be able to take care of the needs of their infants. These mothers are argued to be inclined to have low education levels, less stable partnerships and lower socioeconomic statuses. Older maternal ages (more than 35 years) are equally linked to intrauterine growth restrictions, chromosomal abnormalities, stillbirths and preterm births (Kenny et al., 2013; Newburn-Cook & Onyskiw, 2005; Ngowa et al., 2013). These are attributed to several factors including higher parity and higher risk of hypertension, diabetes, obesity and related pregnancy complications. Some other studies have further shown that older mothers may have children with high blood pressure (Gillman et al., 2004; Lawlor et al., 2004; Roberts et al., 2005; Whincup et al., 1989). According to Fall et al., (2015), a younger maternal age is common in LMICs compared to high-income countries (HICs), and so younger mothers in LMICs may be behaviourally and physically immature to care for their babies.

Mother's Body Mass Index

Maternal Body Mass Index (BMI) is associated with undernutrition, which contributes to foetal growth restrictions leading, to a high risk of neonatal deaths and stunting for survivors by the age of 48 months (Black et al., 2013). It is further argued that maternal overweight and obesity increases the risk of infant mortality. Other studies show that a mother's BMI significantly affects a child's underweight status (Khan et al., 2019).

Breastfeeding

The WHO recommends exclusive breastfeeding to children up to the age 6 months. They further encourage continuous breastfeeding from 6 months to 2 years or beyond with safe, appropriate complementary feeding (WHO 2020). This advocacy is premised on the fact that breastmilk provides all the nutrients and energy required by infants and contains antibodies which helps to protect them against most common childhood diseases. Breastmilk is considered safe and clean and therefore an ideal food for infants. Evidence from rural communities in Mexico shows that stunting is more evident in the fourth month of a child's life when breastfeeding declines. Aheto et al., (2015) report that in Ghana, lower breastfeeding durations relates increased risk of malnutrition. Several other studies corroborate the assertion that breastfeeding improves child health statuses (Matsungo et al., 2017; Oktaria et al., 2017; Scherbaum & Srour, 2016; Walters et al., 2019).

Wealth Status

Poverty has been shown to have a negative effect on child health. Ntshebe et al. (2019) argued that children who live in poorer households are more likely to have poor health. Ambel et al. (2017) found in Ethiopia, using concentrated curves for the years 2000, 2005, 2011 and 2014, that child health outcomes over the period mainly improved for the rich. They also found a considerable gap between the rich and the poor. These are explained along a number of dimensions. Aber et al. (1997) distinguished two types of the state of poverty and their associate cofactors to consider when modelling the relationship between household wealth or poverty and child health. The first are the transitory poor households who briefly fall into poverty due to income fluctuations; the second are the persistently poor who are poor over a longer period of time. Although children who are from persistently poor households experience higher risk of adverse health outcomes, both transitory poor and persistently poor families may face income fluctuations which may force them to change their residence and/or causes emotional stress for parents, which can make them more punitive or less nurturing to their children (Michaelis et al., 1993). Other studies show that poverty results in difficulties in obtaining food, limited access to health services and education, and unemployment (Bouvier et al., 1995; Brown & Solomons, 1991; Delpeuch et al., 2000; Frongillo et al., 1997; Kikafunda et al., 1998; Lipsk et al., 2016; Reyes et al., 2004; Ricci & Becker, 1996; Rikimaru et al., 1998) which ultimately affects child health.

Finally, evidence from Ghana also shows that poor households increase the risk of poor child health (Aheto et al., 2015a).

Household Size

The composition of a household is critical for child health since each member's need compete on the available resources of the household. Accordingly, larger households may not be able to fully satisfy their needs compared to those with smaller size. Gang et al. (2002) found that increase in household size is associated with poverty and attributed to increasing household expenditure which eventually affects child health. Pedraza and de Menezes (2014) corroborated this finding and found that children living in households with six or more individuals are more likely to have poor health than those in a household with less than six members. This is attributed to the competing needs of the available resources.

Residence

The relationship between area of residence and child health, especially stunting, has been explained by differences in beliefs, culture, values and prevailing conditions existing among a subgroup (Van de Poel et al., 2007). Several studies have shown that an individual's residential location influences their health and well-being. In a systematic review, Quansah et al. (2016) found that place of residence (rural-urban disparities) is a critical factor in determining child health and mortality across several Sub-Saharan African countries. They found that lower rates of stunting and child mortality were found in the urban areas in most Sub-Saharan African countries, including Ghana.

Altitude

According to Niermeyer et al., (2009) high altitude is associated with a low-oxygen environment which affects child health. The authors argue that children residing in mountainous areas have risk of several health conditions including: hypoxeamia, acute lower respiratory infection, and high-altitude pulmonary hypertension and oedema. The authors also observed an inverse relationship between altitude and birth weight (which is associated with intrauterine growth restrictions). They argue that poor oxygen delivery during pregnancy hinders foetal development and results in low birth weight. Other studies also argue that high altitude affects child health through inadequate resources and health infrastructure, and that children living in these areas are susceptible to growth retardation, poor nutrition conditions and respiratory infections (Audsley et al., 2016; A. J. Khan et al., 2009).

Summary of Chapter

This chapter presented the theoretical and empirical contributions of literature related to this study to help situate the study in relation to existing knowledge. The theoretical literature explained the theories and concepts underlying the research problem of this study through the following themes: theoretical issues in the conceptualisation of health and health disparities which looked at the concepts and ways of operationalising health inequalities; conceptualisation of place; theoretical conception of health and place which considered the concepts of social capital and proximity; and finally, a review of the structuration theory, externalities, and intersectionality theory and its determinants of health. The empirical literature reviewed related empirical studies with emphasis on methodological contributions and shortcomings relating to neighbourhood characteristics including improved water and its effects on child health, as well as other determinants of child health.

CHAPTER FOUR

METHODOLOGY

Introduction

This chapter presents the research strategy and procedures applied to achieve the objectives of the study. The next section presents the research design describing the advantages and applicability to the present study. This is followed by a description of the data used and sources. The succeeding sections present model specifications, an explanation of variables and estimation techniques for each of the empirical chapters. Finally, procedures for post-estimation diagnostics are presented.

Research Design

According to some authors, being able to justify the decision to adopt or reject a research philosophy should be part of the basis of conducting research (Ryan, 2018). Having a clear understanding of the philosophy will guide the researcher to evaluate the different methodologies, their limitations, and how the selected methods would serve to answer a specific research question (Crossan, 2003). The debate between quantitative and qualitative research has been limited to a focus on methods rather than exploring the underlying philosophy, which is more appropriate to understanding and addressing the research objectives (Clark, 1998).

The present study adopts a positivist philosophy. This approach takes the position that, there is a single version of reality, regardless of the researcher's perspective; hence, the only path to finding this 'truth' is the collection of data to measure or observe independently of others factors. Positivism is considered a progression of empiricism, according to Phillips and Burbules (2000). Empiricism believes that knowledge should be objective and free from researcher bias. Until the beginning of the 20th century, all philosophical research theories involved one single reality independent of that of the researchers (Denzin & Lincoln, 2005). This means that the external reality is discoverable through hypothesis and experimental testing using deductive reasoning (Howell, 2012). The general implications of positivist philosophy include that research is value-free, responds to causality, operationalization, independence, and tends to be quantitative and reductionist (Hughes, 1994).

While some authors declare that the research philosophy outlines the values that guide the entire research – including the collection and analysis of data – others, such as Johnson and Onwuegbuzie (2004), argue that the differences in epistemological beliefs do not entirely dictate the specific data collection and analytical methods to use, hence do not limit the use of either qualitative or quantitative forms of research. Such is the case in the mixed methods approaches.

When deciding on research design, there are several factors to be considered, including the philosophical paradigm, the nature of the phenomenon of interest, the level and nature of the research questions, the main objective of the study and practical considerations regarding the research environment and resources (Crossan, 2003; Shih, 1998). Consistent with the research question of the present study, a quantitative approach was selected, implementing multilevel regression analysis, spatial analysis and spatial regressions.

Research paradigms are generally distinguished in terms of epistemology, or assumptions about how knowledge is generated. In this line, the research design supports previous studies of the same theme from a positivist perspective. Epidemiology, sociology and geography have been successful in re-establishing the interest of neighbourhood and place effects in shaping health and health disparities (Cummins et al., 2007). Some of the relevant research has relied on conventional conceptions of space and place at the individual level; however, Cummins et al. (2007) advocated for extensive quantitative empirical and theoretical research on this subject. In this regard, multilevel analysis has emerged as a new quantitative analytic strategy in several fields, including public health, allowing examinations at the group and individual level (Kawachi & Berkman, 2003).

Quantitative and qualitative research incorporate different methodologies, but are both structured, justified and evaluated under different philosophical bases; hence, they are different paths of knowledge generation. Both approaches have great value for answering research questions at different levels. The possibilities that offer the positivist philosophy leading to a quantitative methodology are the highly controlled procedures and quantifying variables that make it possible to obtain results; continuity of the advances already made in the topic by implementing recommendations from past researchers; and a rigid control of variables leading to findings that could apply to a wider population (Hughes, 1994). Conversely, a major criticism of the positivist approach is that it does not provide an in-depth means to examine human beings and their behaviours (Crossan, 2003); the need to control variables often leads to a small unit of human behaviour being studied;

and that scientific methods from the positivist approach may put the researcher in a more dominant position than the participant which could influence findings (Coolican, 2014).

In conclusion, different philosophies provide us with different paths to generate knowledge in the same topics. However, depending on the nature of the phenomenon of interest, the research questions and other practical considerations, the researcher will select a suitable approach. The positivist philosophy has been shown as essential to public health because of the nature of specific research questions, which is why this study adopts the positivist philosophy and the quantitative approach.

Data Description and Source

Data for the First Empirical Chapter

Data for the first empirical chapter was obtained from the 2014 DHS for Ghana. This survey was carried out by the Ghana Statistical Service (GSS), the Ghana Health Service (GHS), and the National Public Health Reference Laboratory (NPHRL) of the GHS in 2013. DHS 2014 for Ghana is the sixth of the DHS surveys in Ghana since 1988. These household surveys are conducted at five-year intervals and provide reliable information on child and maternal health that is representative of the administrative regions. A two-stage sample design was employed to collect the data: the first, selected 427 sample points (216 urban areas and 211 rural areas) called clusters, consisting of enumerated areas defined for the 2010 Population and Housing Census; the second randomly selected about 30 households from each cluster. In addition to data on health status and its related characteristics among women and children, the survey also recorded the geographic coordinates (latitudes and longitudes) of the clusters. These imply the various geographic locations of the clusters. Figure 6 shows the study locations used in this paper. For the first empirical chapter the study excluded four clusters with missing coordinates and also supplemented the data with district shapefiles obtained from the GIS Remote Sensing Department of the University of Cape Coast.

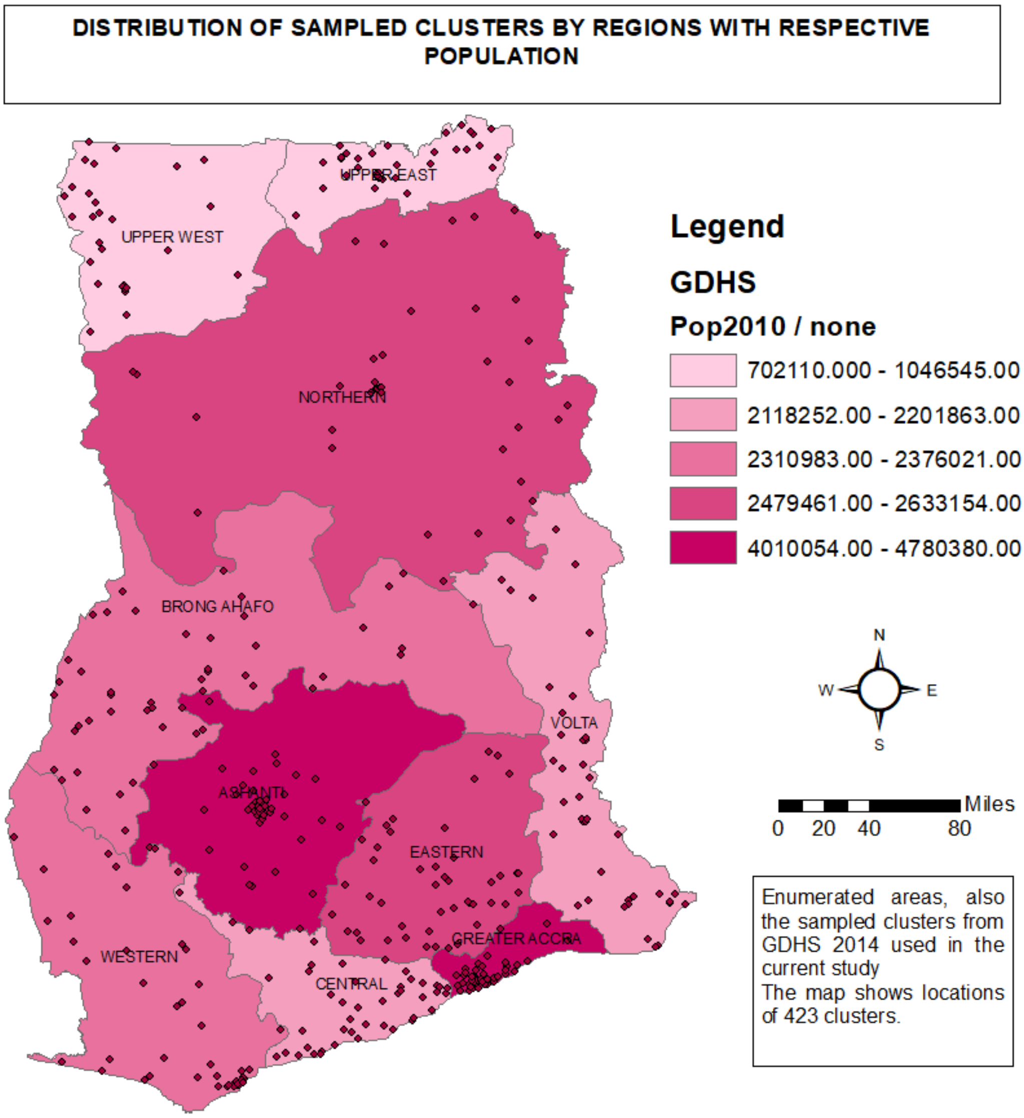


Figure 6: Sampled clusters for DHS, 2014 for Ghana

Source: Agyen (2020)

The study combined these clusters with district-level shapefiles to run estimates at the district level. Figure 7 describes the procedure used to select samples at the individual level and aggregated at the cluster level. First, a total of 83 children who lived in clusters with missing coordinates were excluded. These clusters recorded 0 degrees longitude and 0 degrees latitude each – a point located in the Atlantic Ocean. Therefore children from households whose cluster locations are defined were retained.

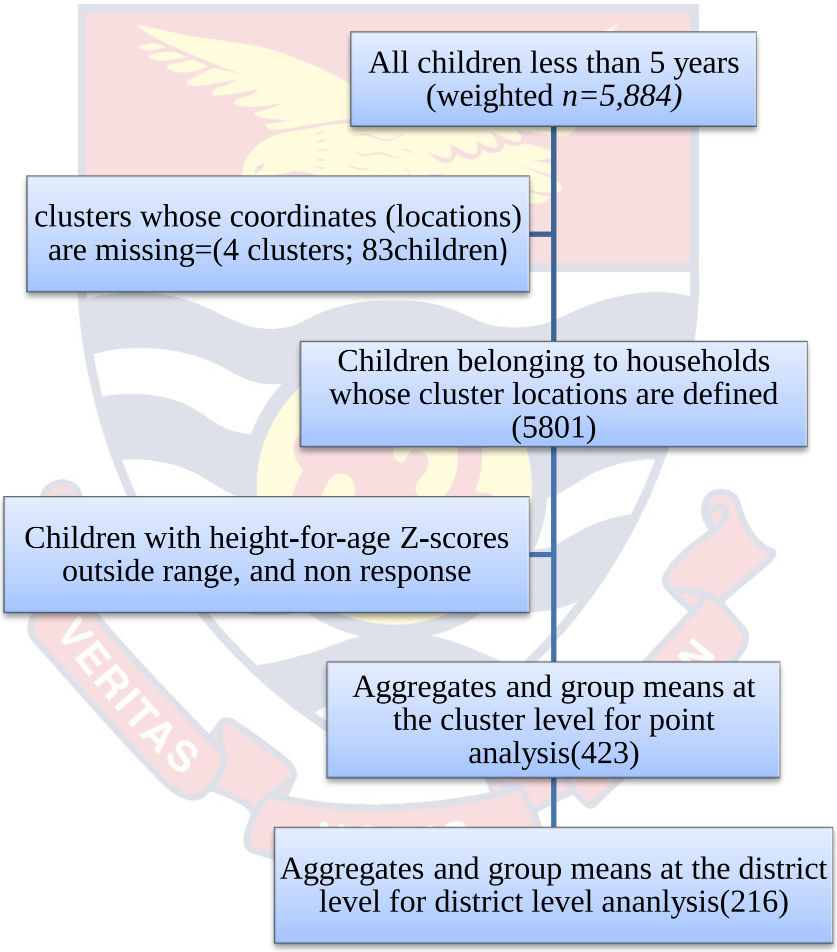


Figure 7: Procedure for sample selection

Source: Agyen (2020)

The study further excluded children whose height-for-age z-scores were not recorded and those outside a range of -5 to 5. Finally, z-scores and variables of interest were aggregated at the cluster and district levels for estimations.

Data for the Second Empirical Chapter

Data for the second empirical chapter was also sourced from the 2014 DHS for Ghana. Here, only children below 5 and whose height for age z-score were recorded and within a range of -5 to 5 were sampled. The study also took into account weight-for-age z-scores within the range -5 to 5.

Data for the Third Empirical Chapter

The study used the DHS datasets from 30 Sub-Saharan African countries. Out of a total of 46 Sub-Saharan countries, DHS collects data from 41 countries. The study excluded seven countries with restricted datasets and four without GPS data or location coordinates for all areas sampled from the country. **Table 2** shows the countries, survey years and the number of children sampled for the study. The study excluded survey years that are more than 10 years ago. Madagascar was the only exception made. The study used the 2008 DHS data for Madagascar. However, this was only used in the spatial analysis but not for other analysis. A sample of 245,426 children (72,544 from urban areas and 172,882 from rural areas) below 5 was used in the spatial analysis, while 233,314 were used in the multilevel analyses.

Table 2: Countries, survey years and sampled under-5 children

	Country	Survey year	Sampled under 5 Children
1	Angola	2016	9,582
2	Benin	2012	11,995
3	Burkina Faso	2010	6,380
4	Burundi	2011	3,588
5	Cameroon	2011	5,079
6	Chad	2015	10,680
7	Comoros	2012	2,739
8	Congo, Democratic Rep.	2014	7,776
9	Cote d'Ivoire	2012	3,330
10	Ethiopia	2010	19,180
11	Gabon	2012	3,511
12	Ghana	2014	2,685
13	Guinea	2012	3,225
14	Kenya	2014	18,869
15	Lesotho	2014	2,940
16	Liberia	2016	5,283
17	Madagascar	2008	12,112[1]
18	Malawi	2016	10,344
19	Mali	2016	4,861
20	Mozambique	2016	9,715
21	Namibia	2013	1,902
22	Nigeria	2015	27,161
23	Rwanda	2015	7,685
24	Senegal	2015	9,980
25	Sierra Leone	2013	4,958
26	Tanzania	2016	15,516
27	Togo	2014	3,214
28	Uganda	2015	2,150
29	Zambia	2014	12,034
30	Zimbabwe	2015	19,064
	Total		245,426

Source: Agyen (2020)

[1] Only included in the spatial analysis.

Figure 8 shows the locations of sampled clusters across countries in Sub-Saharan Africa. A total of 15583 clusters were considered in the third empirical chapter.

Map Showing Sampled Clusters across Countries in Sub-Saharan Africa

Figure 8: Map showing sampled clusters across countries in Sub-Saharan Africa

Source: Agyen (2020)

Theoretical Frameworks and Data Analyses Procedure

The sections that follow presents the theoretical frameworks and data analyses procedures employed for each of the empirical chapters: (1) Spatial Clustering and Neighbourhood Effects of Child Health in Ghana; (2) A Structural Equation Modelling Approach to Examining the Effect of Neighbourhoods on Child Health; and (3) Multilevel and Spatial Analysis of Child Health in the Sub-Saharan Africa Context. For each of the three empirical chapters, the study provides details of the model specification, estimation technique, definition and measurement of variables.

Spatial Clustering and Neighbourhood Effects of Stunting in Ghana

The first empirical chapter addresses three of the objectives of the study. These are (1) identify stunted clusters among children in Ghana (2) examine spatial dependence of stunting in children and (3) determine whether neighbouring mothers' years of education reduces stunting in children.

Unit of Analysis

In addition to individual children, this study used districts and clusters as the main units of analysis. The choice is attributable to two main factors: (1) data and (2) policy. The geographic file in the DHS only provides locations of clusters and not households or individuals. Since the nature of our analysis requires precise and unique location for each unit of analysis, the study used these clusters as the unit of analysis. From a policy perspective, the study combined these clusters with district administrative shapefiles to draw conclusions and make policy recommendations at the district level.

Group means were used since the unit of analysis is at a seemingly larger level. It is appropriate to use group means for research conducted at the city, administrative district, state, national or international level (Barcikowski, 1981).

Measurements of Variables

The response variable is the prevalence of stunting at both the cluster and the district levels. This is measured as the proportion of children between 0 and 59 months whose height-for-age z-score is less than -2 (HAZ<-2) (WHO, 2007). Table 3 presents the definition and measurements of variables used in the individual-level analysis, while Table 4 presents aggregated measures of variables employed in the spatial analysis at the cluster and district level.

Table 3: Definition and measurement of variables for individual-level analysis (logistic and multilevel regressions)

Variable	Definition	Measurement
Child age	Age of the child in categories	Measured as 0 =< 6; 1 = 6 – 8; 2 = 9 – 11; 3 = 12 – 17; 4 = 24 – 35; 5 = 36 – 47; 6 = 48 – 59
Sex of child	Gender of child	0 = female; 1 = male
Mother's age	Age of the mother of the child	Measured in years. Ranges from 15 – 45 years.
Mother's education	Mother's highest educational attainment	0 = no education; 1 = primary; 2 = middle/JSS; 3 = secondary/higher

Table 3, Continued

Variable	Definition	Measurement
Wealth	An index of the wealth status of the household	0 = poorest; 1 = poorer; 2 = middle; 3 = richer; 4 =richest
Ethnicity	Ethnic group	0 = Akan; 1= Ga/Dangbe; 2 = Ewe; 3 = Guan; 4 = Dagbani; 5 = Grusi; 6 = Gurma; 7 = Mande; 8 = Other
Size at birth	Size of the child on delivery	0 = very small; 1 = small; 2 = average
Ever breastfed	Was child ever breastfed?	yes = 0; no = 1
Kids	Number of children in the household	Count of Children below 5years in the Household
Distance problem to health centre	Does household have a distance problem accessing health centre?	0 = yes; 1 = no problem
Urban	Residence status of the household	0 = rural; 1 = urban

Source: Agyen (2020)

Table 4: Definition and measurement of variables for spatial analysis

Variable	Definition
Proportion of poor people	A proportion of households below the middle wealth quintile. Wealth quintile is a composite measure of household cumulative living standard and it is calculated using the aggregate of households' ownership of selected assets.
Mother's education	Average years of education of mothers in a district.
Proportion of children living in rural areas	For every district, the proportion of children who are located in rural areas.
Children who had fever	The proportion of children who had fever within the last two weeks prior to the survey.
Size at birth	The average size of the children at birth.
No improved water source	The proportion of households with no access to improved sources of water.
No easy access to health centre	The proportion of households who find it difficult to access a health centre due to distance.
Children who had diarrhoea	The proportion of children who had diarrhoea within the two weeks prior to the survey.
Proportion Akan	Proportion of children from the Akan ethnic group.
Proportion Ga	Proportion of children from the Ga ethnic group.
Proportion Dagbani	Proportion of children from the Dagbani ethnic group.

Source: Agyen (2020)

Individual-Level Analysis (Logistic and Multilevel Regressions)

The study first employs multilevel analysis and compares the results with a logistic model. The idea of multilevel analysis is basically to help include area (cluster and district) effects after individual-level predictors have been controlled for. With individual children as the unit of analysis, the multilevel analyses allow simultaneous examination of the individual-level predictors and variations within and between clusters and districts.

First, the study considered logistic regression at the individual level where the response variable is binary; thus, 0 for a child aged between 0 and 59 months that is not stunted and 1 for a child aged between 0 and 59 months that is stunted. Taken y as the response variable, the study refers to π as the success probability, where obtaining a stunted child is considered a success; that is, y-value is 1 and a y-value of 0 a failure. The logistic regression estimated is expressed as:

$$\log\left(\frac{\pi_i}{1-\pi_i}\right) = \beta_0 + \beta_1 child\_age_i + \beta_2 child\_sex_i + \beta_3 mothers\_age_i + \beta_4 mothers\_educ_i + \beta_5 wealth_i + \beta_6 Ethnicity_i + \beta_7 size\_at\_birth_{\ i} + \beta_8 ever\_breastfed_i + \beta_9 hh\_Kids_i + +\beta_{10} distance_i + \beta_{11} urban_i \quad (1)$$

Where, $\pi_i/(1-\pi_i)$ is the odds that $y = 1$ and $\log\{\pi_i/(1-\pi_i)\}$ is the log-odds.

Considering a structure where a total of n children are nested within j groups at the cluster or district levels, the response for individual i in group j is denoted by y_{ij} and an individual-level explanatory variable by x_{ij}.

A two-level random intercept model is then specified and estimated as expressed below:

$$\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_0 + \beta_1 child\_age_{ij} + \beta_2 child\_sex_{ij}$$
$$+ \beta_3 mothers\_age_{ij} + \beta_4 mothers\_educ_{ij}$$
$$+ \beta_5 wealth_{ij} + \beta_6 Ethnicity_{ij} + \beta_7 size\_at\_birth_{\ ij}$$
$$+ \beta_8 ever\_breastfed_{ij} + \beta_9 hh\_Kids_{ij}$$
$$+ +\beta_{10} distance_{ij} + \beta_{11} urban_{ij} + u_j \quad (2)$$

Where, $u_j \sim N(0, \sigma_u^2)$. β_0 is the log odds that the response is stunted when $x = o$ and $u = 0$. The exponential of β_0, exp (β_0) gives the odds that a stunted response $(y = 1)$ is obtained when $x = o$ and $u = 0$. The β_s are the effects of a unit change in x on the log odds that y=1 after controlling for the cluster or district effect u. u_j is the cluster or district effect and its variance $var(u_j) = \sigma_u^2$ is the between cluster or district variance adjusted for x. Equation 2 is estimated for both cluster and district-levels.

Exploratory Spatial Data Analysis

The preliminary spatial analysis is based on exploratory spatial data analysis (ESDA) which helps to examine the spatial clustering of stunting in Ghana. Following Anselin (1998), the study employed ESDA which entails a collection of techniques for the statistical analysis of geographic information. This helped us to visualize the spatial distribution of stunting, identify spatial outliers (if any), and discover patterns of spatial association, clusters or hot spots. First, the data is visualized using choropleth maps to assess patterning. We then applied ESDA to district-level child health outcomes in Ghana to lay bare areas or administrative districts of higher risk. The ESDA techniques used in this paper helps to assess local patterns of spatial autocorrelation in each district through the implementation of Local Indicators of Spatial Association (LISA) statistics.

For each district, we tested if the stunting rate observed is similar to its immediate neighbours, implying a positive spatial autocorrelation or dissimilarity to that of the neighbours; in this case, a negative spatial autocorrelation.

The first empirical chapter used the Moran's I statistic to measure the existence and extent of global clustering. It was assessed by testing the null hypothesis that the spatial patterns of the DHS data used were random. A rejection of the null hypothesis, therefore, means a non-random spatial pattern which is also referred to as spatial autocorrelation. More specifically, positive spatial autocorrelation indicates that similar values occur at adjacent locations; whereas negative autocorrelation implies that high values appear next to low values. Moran's I ranges approximately from +1 (for positive spatial autocorrelation) to -1 (negative autocorrelation), and its expected value in the absence of autocorrelation approximates 0 (Anselin, 1998). The Local Moran I, which helps to evaluate autocorrelation in each district is formally specified as:

$$I_i = \frac{(n-1)\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\,(y_i-\bar{y})(y_j-\bar{y})}{\sum_{i=1}^{n}\sum_{j=1}^{n}(y_i-\bar{y})^2} \quad (3)$$

Where w_{ij} is defined as the spatial weight between i and j.

Global Moran I, on the other hand, measures spatial autocorrelation for the entire study area:

$$I = \left[\frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}}\right] \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\,(y_i - \bar{y})(y_j - \bar{y})}{\sum_{i=1}^{n}(y_i - \bar{y})^2} \tag{4}$$

To reduce the impact of population heterogeneity on the estimates and mapping, the study adopted the empirical bayes-based smoothing (Lemon & Krutchkoff, 1969). This is to help reduce biases associated with varying size of populations (Diehr, 1984).

Defining Neighbours

Queen's case adjacency, a contiguity-base spatial weight which defines a neighbour base on sharing a common boundary or vertex in all directions, was used to define neighbour relationships. The neighbours of district i include all districts sharing at least a corner with district i. For cluster-level analysis the study created Theissen polygons where neighbours are polygons that share same boundary, as shown in Appendix H.

Models and Estimation Techniques

The choice of multilevel and spatial regressions is attributable to the fact that conventional methods and standard statistical tests strongly consider the assumption of independence of observations. While these methods have been used by several studies that have examined the same area of interest (i.e. stunting in children) with the same dataset, such standard multivariate analyses are potentially flawed. This is because the data was collected using a two-stage sampling design, which makes the data structure, hierarchical. Due to the possibility of ecological attributes of spatially defined areas that affect whole groups or shared characteristics of people in the same area/cluster/district, individual observations in such samples are generally not completely independent. The violation of the assumption of independent observations results in smaller and clustered standard errors of conventional statistical methods, which lead to spurious results. To this end, this study considers the "spatial" nature of the data and incorporates it into the models to avoid false indications of significance, biased parameter estimates and misleading suggestions of fit (Anselin 1998; Cressie 2015; Messner et al., 1999).

Spatial Lag Model

First, Ordinary Least Square (OLS) was constructed model where the proportion of stunted children in each district is assumed to be independent of all other districts across the country.

$$y = X\beta + \varepsilon, \quad (5)$$

Where y is an $N \times 1$ vector of proportion of stunted children in a district ($N = 216$ districts). The independent measures are captured in X, which is a $216 \times k$ matrix, where $k = 6$, the total number of explanatory variables and β is a 6×1 vector of regression coefficients. We then incorporate spatial dependence into the standard linear regression by adding the spatially lagged dependent variable (Wy) as an additional independent variable which is formally, expressed as

$$y = \rho Wy + X\beta + \varepsilon, \quad (6)$$

Where ρ is a spatial autoregressive coefficient, ε is a vector of error terms.

Spatial Error Model

Again, the OLS model is extended to include spatial dependence in the regression disturbance term. This helps to verify by comparing with other models if spatial autocorrelation is attributable to spatial data. The model is specified as

$$y = X\beta + \lambda Ws + \varepsilon \quad (7)$$

Spatial Two-Stage Least Squares

From the reduced form of the spatial lag model, the spatial lag term $(Wy)$is evidently correlated with the errors:

$$y = (I - \rho W)^{-1}X\beta + (I - \rho W)^{-1}\varepsilon \quad (8)$$

This raises endogeneity concerns, and so the need to treat the spatial lag term as an endogenous variable. Instrumental variable or two-stage least squares was used to do away with the endogeneity of the spatially lagged dependent variable (Anselin, 1990, 1998; Kelejian & Prucha, 1998). Following Kelejian and Robinson (1993) the study use the spatial lags of the explanatory variables.

Spatial Cross-Regressive Model (SLX Model)

We estimated the effect of neighbourhood mothers' education by employing the spatial cross-regressive model (SLX model). We include the lag of the average years of schooling of neighbouring mothers (WX_2). The model is thus specified as

$$y = X\beta + WX\gamma + \varepsilon \quad (9)$$

More specifically,

$$y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \gamma_2 W x_2 + \varepsilon \quad (10)$$

where y is the dependent variable and γ_2 the parameter of the coefficient of Wx_2(lag of the average years of schooling of neighbouring mothers)

A Structural Equation Modelling Approach to Examining the Effect of Neighbourhoods on Child Health in Ghana

Owing to the complex and multi-faceted concepts involved in achieving the objectives, the study employs structural equation modelling, a general modelling framework that integrates several multivariate techniques. It enables the estimation of a more complex system of relationships and mediated effects rather than a multivariate regression model. The study also employs this modelling framework to be able to examine the indirect or mediated and direct effects of variables on child health.

Spatial Effect as a Latent Variable

The study adopted Folmer and Oud's (2008) approach of incorporating and testing more information on spatial dependence by using latent variable to represent spatial dependence or spill over effects rather than using weights.

The study introduced spatial effect as a latent variable in a structural equation model. In this model, spatial effect is thought of as the underlying cause of the observed variables; residence, distance to health centre, source of drinking water, sanitation, neighbours' wealth, and neighbouring mothers' education. This is due to the fact that the concept of spatial effect is not directly observable.

Justification of Observed Variables

Source of Drinking Water

Fresh water is important and an absolute necessity for subsistence and the development of human society (Ballantine et al., 2012; Everard, 2002) However, groundwater which stores the world's fresh water takes hundreds of years to recharge once water is extracted from its aquifers (Oki et al., 2003). More than 99 per cent of surface water which serves as the readily available water resource to humans cannot be used by humans and many other living things; merely 0.3 per cent is considered fresh (Society, 2012).

Unlike groundwater, which takes a long time to recharge, water circulation systems can expeditiously replenish surface water (Kellogg, 1997). However, an attribute of surface water is its uneven distribution (Dzhamalov et al. 2015; Kanakoudis et al. 2016). Factors such as population growth associated with pollution, economic development, changes in land use and salt water intrusion affect the state of water in an area (You et al., 2018; Kanakoudis, et al., 2017a, 2017b; Vörösmarty et al., 2000). To this end, the study treats improved sources of drinking water as varying in space.

The study follows the WHO's definition of improved water as water from sources that are protected from contamination – especially from faecal matter. These include piped, borehole, protected well, protected spring and rainwater collection.

Sanitation

Improved sanitation is essential for reducing the risks of adverse health outcomes (Andrade et al., 2009). Following the WHO definition, "improved sanitation includes a flush toilet, septic tank, piped sewer system, flush to open pit, compositing toilet, a ventilated improved pit latrine or a pit latrine with a slab" (WHO & UNICEF, 2014). In addition to the stark disparities of sanitation across regions and between rural and urban areas (WHO & UNICEF, 2014), it has been found to demonstrate spatial effects (Jia et al., 2016).

Residence type

Residence defines the type of place in which the household of a child is located. It is classified into urban and rural. Urban areas include large cities with populations of over 1 million, small cities with populations over 50,000 and towns. Rural areas comprise of areas in the countryside (The DHS Program, 2013).

Distance to Health Centre

This measures whether or not the individuals in a household face difficulty with the geographic distance from the household to the nearest health centre. The relationship through which space or neighbourhood could affect health as proposed by Bernard et al. (2007) is proximity shaped by the social environment.

Neighbours' Wealth

Neighbours' wealth here is characterised by the average of the wealth status of all households that share the same cluster identity with an individual household, excluding the household itself. The study followed spatial regression techniques of defining spatial dependence (measuring the average influence of neighbouring observations on observations of some variable) to define the neighbours' wealth and adopted Folmer and Oud's (2008) approach of estimating this effect.

Neighbouring Mothers' Education

Neighbouring mothers' education measures the average years of education of all mothers in the same cluster, other than the individual's own mother. This helps to measure similarity relationships among mothers in the same neighbourhood.

The Path Model

The study uses confirmatory factor analysis which uses a restricted model presented in Figure 9. The specification of the model is based on a combination of the intersectionality model, social capital and empirical results from literature. The commission for the social determinants of health (CSDH) framework[2] was adopted to identify the social and environmental conditions and trajectories for child health (that is HAZ and WAZ). The conventions used in the model are presented in Appendix I and the description of the variables are presented in Appendix K.

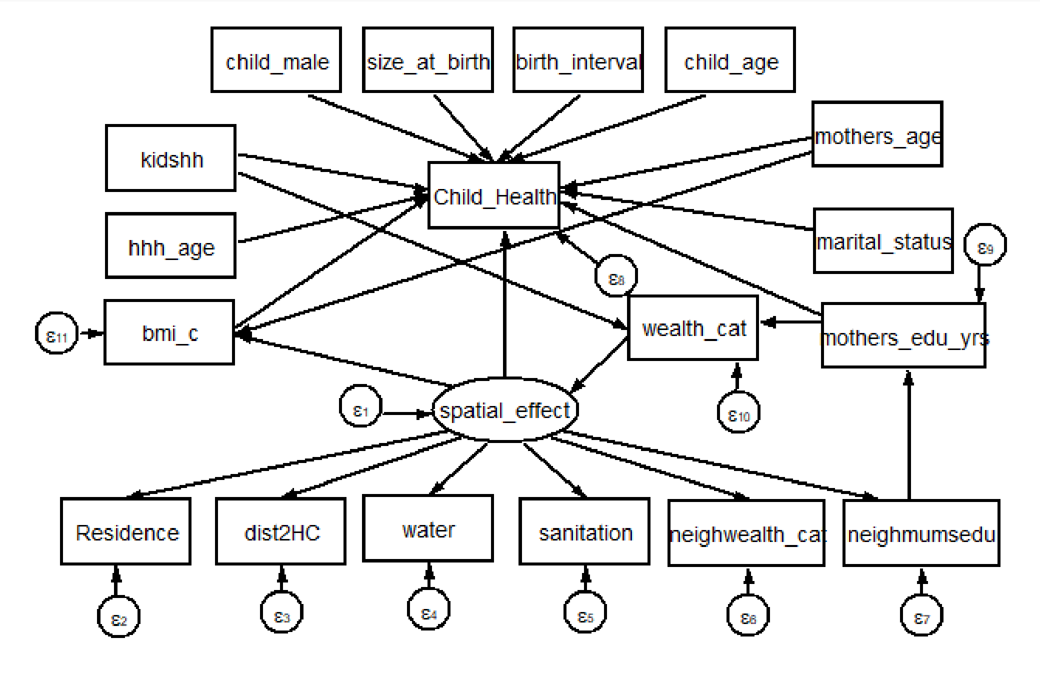


Figure 9: Pathways that connects neighbourhood effects and child health outcomes

Source: Agyen (2020)

[2] See Appendix J: CSDH Conceptual Framework

The study identifies neighbourhood effects termed spatial effects in this model as determinant of child health, with the potential of influencing individual-level characteristics. The model postulates that neighbourhood effects intrinsically relates the indicator/observed variables; residence, distance to health centre, source of drinking water, sanitation, neighbours' wealth, and neighbouring mothers' education. More specifically the model seeks to help assess if the years of education of all other mothers in the same cluster relates an individual's own mother's education which ultimately lead to an increase in HAZ and WAZ scores. The link between neighbourhood mothers' education and a mother's education may also lead to increase in household wealth and a ripple effect in the neighbourhood.

The model considers relationships between the determinants of child health. The study examines the relationship between mother's education on child health partly mediated by the mother's BMI due to the increase in storage of fats associated with age (Karolinska Institutet, 2019). It also examines the relationship between mother's BMI and spatial effect due to clustering of obese women in Ghana (Dake, 2012); and the relationship between the number of children in a household and the household wealth, attributed to increased expenditure and competition on resources (Gang et al., 2002).

Estimation Technique

The method for estimating the structural equation models used in this study is maximum likelihood (ML) under the assumption of multivariate normality as suggested by Tong and Bentler (2013).

Goodness-of-Fit of the Model

In addition to the test of the coefficient estimates for each of the individual parameters, the study used different indicators to assess the overall goodness-of-fit of the model. The indicators used include adjusted chi-square test (x^2/degrees of freedom), the Tucker-Lewis Index (TLI), the comparative fit index and the root mean squared error of approximation (RMSEA). According to Bagozzi and Yi (1988); Hair, Black, Babin, and Anderson (2010); and Hu and Bentler (1999), a model is considered as a good fit to the data if the CFI and TLI values are close to 1 and the value of RMSEA is low, preferably below 0.05.

Stability of the model was equally ascertained. A model is considered stable, if the reported estimates are said to yield a stable model when the stability index is less than 1.

Multilevel and Spatial Analysis of Child Health in the Sub-Saharan Africa Context

This empirical chapter delved into neighbourhood effects using a larger dataset and helped expose some basic shortfalls of employing the traditional multivariate regressions. The hypotheses to be tested are:

i. Mothers' with secondary and/or higher education in a neighbourhood significantly improves a child’s health over and above the child's own mother's education

ii. The relationship between the proportion of mothers’ education and child stunting is mediated by the residence of the child.

iii. The effect of improved water on stunting differs across neighbourhoods.

The data have a clustered or hierarchical structure, and so observations may tend to be more alike in their social characteristics. Thus, individual children nested within geographical areas may have similar characteristics. The study used multilevel models to recognise the existence of clustering in the data. If the prevalence of stunting is clustered by geographical area, and this is not taken into account in the estimation as in the traditional logistic regression, the standard errors of the regression coefficients will generally be underestimated (McNeish, 2014). To obtain correct standard errors, variation among groups is allowed for in the analysis. Multilevel models provide efficient means of controlling for clustering and allow for the residual components at each level in the hierarchy as shown in equation 11.

A two-level model was used to allow for grouping of child health outcomes within geographical areas to include residuals at the child level and the geographical area (or neighbourhood) level. The dependent variable is binary, where 0 is the response for a child who is not stunted and 1 is for stunted.

Table 5: Definition and measurement of variables used in the third empirical chapter

Variable	Definition	Measurement	Abbreviation
Child age	Age of the child in categories	measured as 0 =< 6; 1 = 6 – 8; 2 = 9 – 11; 3 = 12–17; 4 = 18 – 3; 5 = 24 – 35; 6 = 36 – 47; 7 = 48 – 59	Child_age
Sex of child	Gender of child	1 = male; 2 = female	Child_sex
Size at birth	Size of the child on delivery	0 = very small; 1 = small; 2 = Average	Size_at_birth

Table 5, Continued

Variable	Definition	Measurement	Abbreviation
Mother's education	Mother's highest educational attainment	0 = No education; 1 = Primary; 2 = Middle/Secondary; 3 = higher	Mothers_educ
Mother's age	Age of the Mother of the child	Measured in years. Ranges from 15 – 45 years	Mothers_age
Improved water source	Source of drinking water	0 = not improved; 1 = improved	Imp_water
Improved sanitation	Improved toilet facility	0 = not improved; 1 = improved	Imp_sanitation
Wealth	An index of the wealth status of the household	0 = Poorest; 1 = Poorer; 2 = Middle; 3 = Richer; 4 = Richest	wealth
Age of head of household	Age of the head of household	measured in years. ranges from 15 years to 95years	Hhh_age
Ever Breastfed	Was child ever breastfed	yes = 0; no = 1	Ever_breastfed
Residence	Residence status of the household	1 = urban; 2 = rural;	residence
Altitude	Cluster's elevation in meters above sea level	Measured in meters. Ranges from -92 to 3563meters	Altitude

Table 5, Continued

Variable	Definition	Measurement	Abbreviation
Proportion of mothers with secondary levels of education	Proportion of mothers with at least secondary levels of education in each cluster	Aggregated individual mothers' secondary education at the cluster level	Mothers_educ2 _means
Proportion of mothers with higher levels of education	Proportion of mothers with higher levels of education in each cluster	Aggregated individual mothers' higher education at the cluster	Mothers_educ3 _means

Source: Agyen (2020)

Model specification

First, the multilevel model without contextual effect of the proportion of mothers' education is specified as:

$$\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_0 + \beta_1 child\_age_{ij} + \beta_2 child\_sex_{ij} + \beta_3 size\_at\_birth_{ij} + \beta_4 mothers\_educ_{ij} + \beta_5 mothers\_age_{ij} + \beta_6 imp\_water_{ij} + \beta_7 imp\_sanitation_{ij} + \beta_8 wealth_{ij} + \beta_9 hhh\_age_{ij} + \beta_{10} ever\_breastfed_{ij} + \beta_{11} residence_j + \beta_{12} altitude_j + \mu_{0j} \quad (11)$$

The study then estimates two random intercept models introducing the contextual effect of mothers' secondary and higher education (equations 12 & 13 respectively). These are to test that neighbourhood mothers' education positively affects a child's health status over and above the effect of his/her own mother's level of education:

$$\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_0 + \beta_1 child\_age_{ij} + \beta_2 child\_sex_{ij} + \beta_3 size\_at\_birth_{ij} + \beta_4 mothers\_educ_{ij} + \beta_5 mothers\_age_{ij} + \beta_6 imp\_water_{ij} + \beta_7 imp\_sanitation_{ij} + \beta_8 wealth_{ij} + \beta_9 hhh\_age_{ij} + \beta_{10} ever\_breastfed_{ij} + \beta_{11} residence_j + \beta_{12} altitude_j + \beta_{13} mothers\_educ2\_means_j + \mu_{0j} \quad (12)$$

$$\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_0 + \beta_1 child\_age_{ij} + \beta_2 child\_sex_{ij} + \beta_3 size\_at\_birth_{ij} + \beta_4 mothers\_educ_{ij} + \beta_5 mothers\_age_{ij} + \beta_6 imp\_water_{ij} + \beta_7 imp\_sanitation_{ij} + \beta_8 wealth_{ij} + \beta_9 hhh\_age_{ij} + \beta_{10} ever\_breastfed_{ij} + \beta_{11} residence_j + \beta_{12} altitude_j + \beta_{13} mothers\_educ3\_means_j + \mu_{0j} \quad (13)$$

The study further tests the interaction effect of residence and the proportion of mothers with at least secondary education. Thus, equation 14 tests the main hypothesis that the relationship between the proportion of mothers' education (secondary education) and child stunting is mediated by the residence of the child.

$$\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_0 + \beta_1 child\_age_{ij} + \beta_2 child\_sex_{ij} + \beta_3 size\_at\_birth_{ij} + \beta_4 mothers\_educ_{ij} + \beta_5 mothers\_age_{ij} + \beta_6 imp\_water_{ij} + \beta_7 imp\_sanitation_{ij} + \beta_8 wealth_{ij} + \beta_9 hhh\_age_{ij} + \beta_{10} ever\_breastfed_{ij} + \beta_{11} residence_j + \beta_{12} altitude_j + \beta_{13} mothers\_educ2\_means_j + \beta_{14} mothers\_educ2\_means\#residence_j + \mu_{0j} \quad (14)$$

where, β_{14} is the interaction effect of the proportion of mothers with secondary education and residence.

Equations 15, 16 and 17 were used to test that the effect of improved water sources on stunting varies across neighbourhoods. The study defined improved water following the WHO and UNICEF (2014) definition as water from sources that are protected from contamination. Included in this study are “piped water into dwelling”, “piped into yard/plot”, “piped to neighbour’s house”, “borehole with pump”, “protected well”, “protected spring” and “bottled water”.

Equation 15 tests that the effect of improved water sources on stunting depends on the altitude of the neighbourhood. This is specified as:

$$\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_0 + \beta_1 child\_age_{ij} + \beta_2 child\_sex_{ij} + \beta_3 size\_at\_birth_{ij} + \beta_4 mothers\_educ_{ij} + \beta_5 mothers\_age_{ij} + \beta_6 imp\_water_{ij} + \beta_7 imp\_sanitation_{ij} + \beta_8 wealth_{ij} + \beta_9 hhh\_age_{ij} + \beta_{10} ever\_breastfed_{ij} + \beta_{11} residence_j + \beta_{12} altitude_j + \beta_{13} mothers\_educ2\_means_j + \beta_{14} imp\_water\#altitude_{ij} + \mu_{0j} \quad (15)$$

where β_{14} in equation 15 is the interaction effect of improved water and the altitude of the neighbourhood.

Equation 16 tests the hypothesis that the effect of improved water sources on stunting depends on the residence (that is, rural or urban) of the child. This is specified as:

$$\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_0 + \beta_1 child\_age_{ij} + \beta_2 child\_sex_{ij} + \beta_3 size\_at\_birth_{ij} + \beta_4 mothers\_educ_{ij} + \beta_5 mothers\_age_{ij} + \beta_6 imp\_water_{ij} + \beta_7 imp\_sanitation_{ij} + \beta_8 wealth_{ij} + \beta_9 hhh\_age_{ij} + \beta_{10} ever\_breastfed_{ij} + \beta_{11} residence_j + \beta_{12} altitude_j + \beta_{13} mothers\_educ2\_means_j + \beta_{14} imp\_water\#residence_{ij} + \mu_{0j} \quad (16)$$

The study also use equation 16 to test the hypothesis that the effect of specific improved water source (piped water) on stunting depends on the residence.

we test the random slope model as shown in equation 17:

$$\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_0 + \beta_1 child\_age_{ij} + \beta_2 child\_sex_{ij} + \beta_3 size\_at\_birth_{ij} + \beta_4 mothers\_educ_{ij} + \beta_5 mothers\_age_{ij} + \beta_6 imp\_water_{ij} + \beta_7 imp\_sanitation_{ij} + \beta_8 wealth_{ij} + \beta_9 hhh\_age_{ij} + \beta_{10} ever\_breastfed_{ij} + \beta_{11} residence_j + \beta_{12} altitude_j + \beta_{13} mothers\_educ2\_means_j + \mu_{0j} + u_{6j} imp\_water_{ij} \quad (17)$$

Equation 17 allows the relationship between improved water sources and child health (stunting) to vary across neighbourhoods. The term u_{6j} is added to the model so that the effect of improved water now becomes $\beta_{6j} = \beta_6 + u_{6j}$. The neighbourhood level residuals now are μ_{0j} and u_{6j}, which are assumed to follow a bivariate normal distribution with mean vector 0 and variance-covariance matrix Ω_u.

$$\begin{pmatrix} u_{0j} \\ u_{6j} \end{pmatrix} \sim MVN(0, \Omega_u), \qquad 0 = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \qquad \Omega_u = \begin{pmatrix} \sigma_{u0}^2 & \\ \sigma_{u06} & \sigma_{u6}^2 \end{pmatrix}$$

The subscript '6' of the slope residual and its variance and covariance is explained by the position of the variable, improved water in the model (equation 17).

Model Comparison

The study adopted the model comparison approach to hypothesis testing. The likelihood ratio test is used for the comparison of models. The likelihood ratio is the ratio of the likelihoods of the two models being compared. Under the assumption that the less restrictive model is true, the transformed likelihood ratio is given as $-2 \times \log_e(likelihood\ ratio)$. The transformed likelihood ratio is asymptotically distributed as the x^2 distribution. The degree of freedom used, is the difference in the number of parameters between the two models under comparison (Prins & Kingdom, 2018).

Chapter Summary

This chapter outlines the methodologies used in this study. It justifies the adoption of the positivist approach and the use of the quantitative approach based on the problem statement, purpose, and research objectives of the present study. Spatial analysis and spatial regression methods (spatial lag and spatial error models) were adopted based on the inherent residential disparities examined in the DHS data to examine the spatial nonrandomness in child health. Multilevel logistic regression was adopted based on the dependent variable which is binary to examine variations across subgroups.

The results and discussions from these methods are presented in the next chapters. Insights into the determinants of child health and drivers of child health variations are presented.

CHAPTER FIVE

SPATIAL CLUSTERING AND NEIGHBOURHOOD EFFECTS OF STUNTING IN GHANA

Introduction

This chapter provides an empirical analysis of child health inequality in Ghana by examining two main objectives; to examine spatial dependence of stunting in children in Ghana, and to determine whether neighbourhood characteristics – especially, neighbouring mothers' years of education – reduce child stunting. The chapter identifies clusters of stunted children across districts in Ghana. First, is a presentation of some descriptive statistics of stunting across the regions and districts of the country. The empirical analyses on the three objectives then follow in the subsequent sections.

Descriptive Statistics

This section provides some choropleth maps of stunting in Ghana from (DHS, 2014). Figure 10 shows regional distribution of stunting. Consistent with the 2014 GDHS report, Northern region had the highest prevalence rate of 33 per cent followed by Central region, 22 per cent and Upper West 21 per cent. Greater Accra, however, recorded the lowest rate of 10 per cent followed by Ashanti and Upper East regions, each recording a rate of 14 per cent.

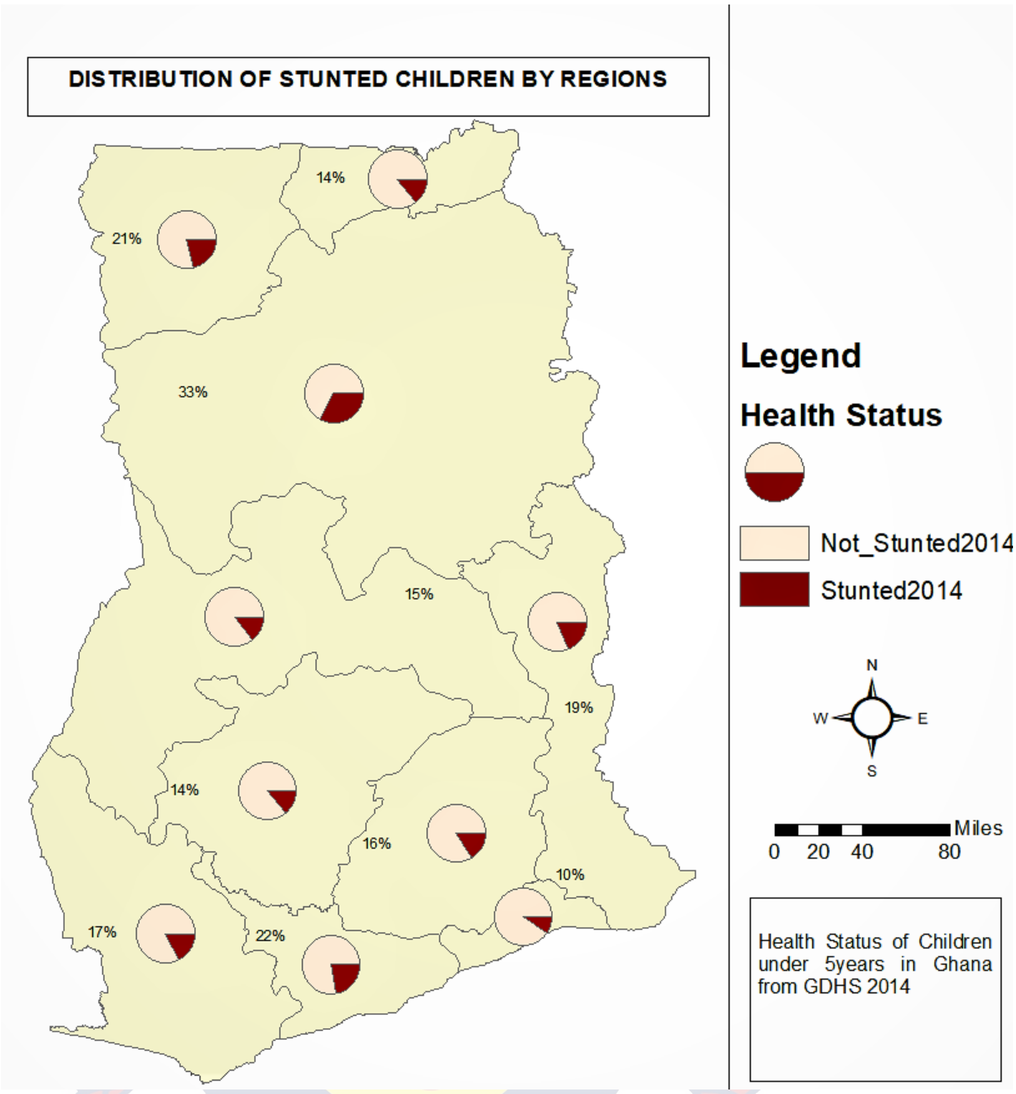


Figure 10: Distribution of stunted children across regions in Ghana

Source: Agyen (2020)

The study further zoomed in to view the prevalence rate across districts in Ghana. The results show that some districts in the eastern part of the Northern region and the upper part of the Volta region recorded rates above the current world prevalence rate of 22.2 per cent. These are clusters of higher stunting levels indicating poor child health status. A more worrying observation is the pockets of stunting rates in the southern part of the country, especially parts of the Eastern, Ashanti, Western and Greater Accra regions, where higher rates are offset by districts with lower rates in the same region. Although the Greater Accra region recorded the lowest rate, the Ledzokuku Krowor municipal also in the Greater Accra region, recorded figures as high as 30 per cent. There are 79 districts with rates above the national level of 19 per cent. Among these districts, 68 recorded rates above the current world prevalence rate of 22.2 per cent and 11 recorded rates that fell between the national and world rates.

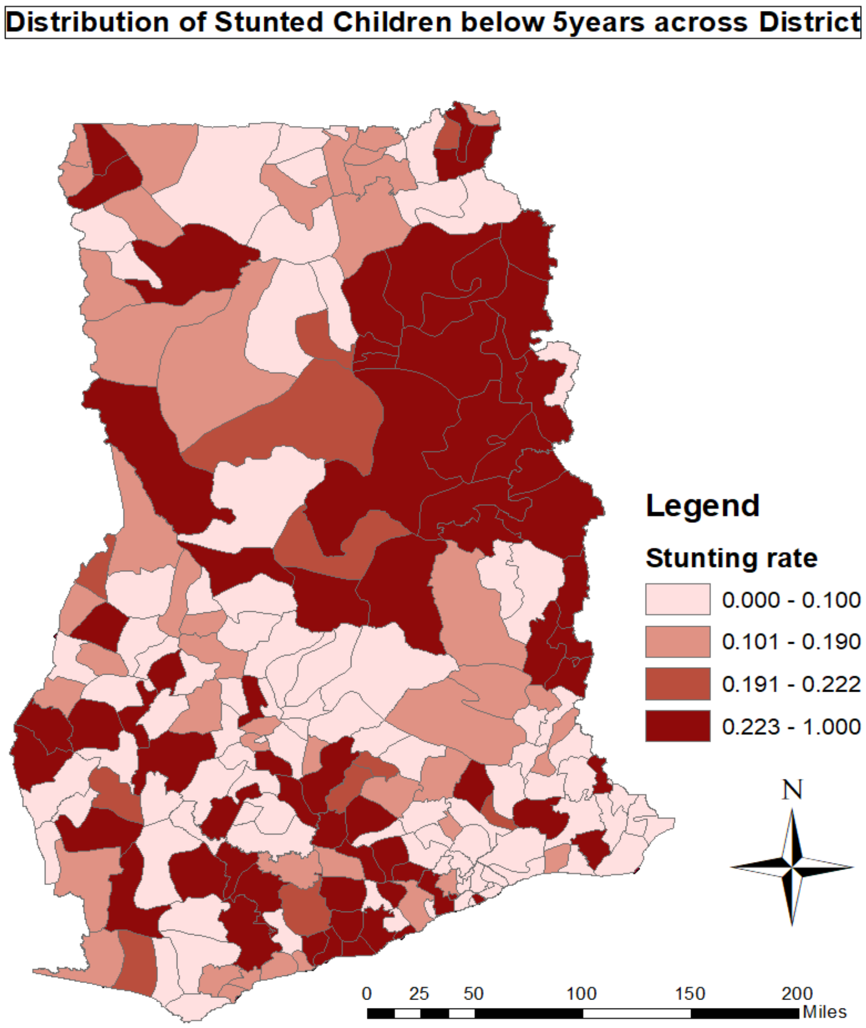


Figure 11: Distribution of under-5 stunted children across districts

Source: Agyen (2020)

Individual-Level Estimation Results

The study analyses data on children with eligible z-scores for stunting. At the individual level, the study used a multilevel logistic model to examine the presence of variations in stunting at the cluster and district level. Estimates of these multilevel logistic models are compared with the standard logistic model to ascertain the best model. The results are presented in **Table 6**.

Table 6: Results for logistic versus multilevel models for stunting

	Models					
Stunting	**Logistic**		**Multilevel (Cluster)**		**Multilevel (District)**	
Fixed Effects: Individual-level	**Odds Ratio**	**Std. Error**	**Odds Ratio**	**Std. Error**	**Odds Ratio**	**Std. Error**
Intercept	0.286***	(0.131)	0.261**	(0.125)	0.280**	(0.133)
Child age (Base= Below 6)						
6-8	1.148	(0.455)	1.135	(0.460)	1.280	(0.520)
9-11	1.568	(0.619)	1.561	(0.620)	1.701	(0.678)
12-17	2.763***	(0.804)	2.820**	(0.842)	2.864**	(0.868)
18-23	5.137***	(1.502)	5.467***	(1.638)	5.644***	(1.709)
24-35	6.127***	(1.872)	6.548***	(2.047)	6.811***	(2.144)
36-47	4.015***	(1.296)	4.204***	(1.384)	4.323***	(1.433)
48-59	2.605**	(0.857)	2.562**	(0.860)	2.761**	(0.933)
Sex of child (Base = Female)						
Male	1.372**	(0.143)	1.414**	(0.155)	1.426**	(0.155)
Mother's age	0.988	(0.008)	0.989	(0.008)	0.987	(0.008)
Mother's education (Base=No education)						
primary	0.755+	(0.112)	0.767*	(0.123)	0.773	(0.123)
Middle/JSS	0.556***	(0.874)	0.559**	(0.094)	0.566**	(0.094)
Secondary/higher	0.234***	(0.074)	0.232***	(0.073)	0.230***	(0.071)
Wealth (Base=Poorest)						
Poorer	1.046	(0.151)	0.999	(0.166)	0.962	(0.157)
Middle	0.789	(0.142)	0.705+	(0.148)	0.706+	(0.144)
Richer	0.700	(0.166)	0.617+	(0.155)	0.635+	(0.156)
Richest	0.431**	(0.131)	0.367**	(0.121)	0.386**	(0.125)
Et hnicity (Base =Akan)						
Ga/Dangbe	0.481*	(0.168)	0.441*	(0.167)	0.437*	(0.163)
Ewe	0.634*	(0.122)	0.642*	(0.135)	0.651*	(0.138)
Guan	0.863	(0.290)	0.827	(0.306)	0.788	(0.286)
Dagbani	0.731*	(0.113)	0.696*	(0.126)	0.667*	(0.122)
Grusi	0.314***	(0.094)	0.278***	(0.100)	0.265***	(0.095)
Gurma	1.107	(0.212)	0.949	(0.235)	0.942	(0.226)
Mande	0.743	(0.352)	0.747	(0.372)	0.730	(0.357)
Other	0.892	(0.366)	0.931	(0.393)	0.904	(0.373)
Size at birth (Base=very small)						
Small	0.460**	(0.115)	0.456**	(0.122)	0.469**	(0.124)
Average	0.363***	(0.074)	0.344***	(0.078)	0.358***	(0.080)
Ever breastfed(Base=yes)						
No	1.248	(0.238)	1.277	(0.253)	1.286	(0.254)

Table 6, Continued.

	Logistic		Multilevel (Cluster)		Multilevel (District)	
	Odds Ratio	Std Error	Odds Ratio	Std Error	Odds Ratio	Std Error
Kids	1.165**	(0.067)	1.180**	(0.074)	1.164**	(0.072)
Distance problem to health centre (Base =problem)						
Not a problem	0.918	(0.110)	0.867	(0.113)	0.836	(0.107)
Residence(Base=rural)						
Urban	1.067	(0.162)	1.136	(0.197)	1.055	(0.171)
Random effects:Std deviation			0.548***	(0.110)	0.449***	(0.093)
Intra-class correlation			0.084**	(0.031)	0.058**	(0.023)
Groups			418		191	
Observations	2,709		2,709		2,675	
Log-likelihood	-1173.95		-1168.48		-1150.74	

*+p<0.1; *p<0.05; **p<0.01; ***p<0.001*

Source: Agyen (2020)

Table 6 indicates that the odds of being stunted for children above 12 months of age are higher than the odds for those below 6 months. For the logistic regression model and the multilevel regression models, male children were found to have higher odds of being stunted compared to females. We also observed lower odds of being stunted with primary, secondary and higher levels of education of the mother, compared to those from mothers with no education. The results also show that wealth improves the health status of the child. Ethnicity was found to be significant to child health in all models. There was also evidence of significance of the size of the child at birth and the number of children in a household.

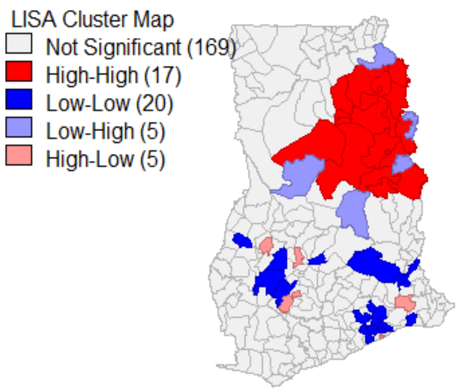
Most importantly, there was significant cluster and district-level variations in the multilevel regression analysis. After controlling for individual-level explanatory variables, the study found that 8.4 per cent and 5.8 per cent of the variations in stunting are between clusters and districts respectively. Though modest in size, such low intra-class correlations can be misleading, since the square root of these values stands for the total estimated effect size (Raudenbush & Sampson, 1999). Significant variability across district and clusters were observed (District: 0.548; cluster; 0.499)

The Spatial Autocorrelation of Stunting

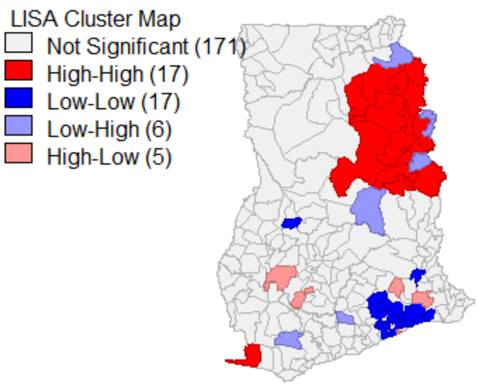
Results for local test for spatial autocorrelation which measures the degree to which child health outcomes are similar in neighbouring areas (districts) are presented in Table 7 The results show categories of spatial dependence at the district level: “high-high” and “low-low”. A high-high category indicates clustering of high values of stunting rates, while a low-low category indicates clustering of low values. These outcomes suggest that there is a positive spatial autocorrelation. In addition, a high-low category indicates that high values are adjacent to low values of unadjusted prevalence rates, while a low-high category indicates that low values are adjacent to high values. These outcomes also suggest a negative spatial autocorrelation. Lastly, there were also areas of no statistically significant spatial autocorrelation. The unadjusted LISA of stunting rates in (a) of Table 7 show that 17 districts with high prevalence of stunting are adjacent to other districts with equally high prevalence of stunting. All 17 districts are located in the north eastern part of the country. The adjusted LISA by empirical Bayes-based smoothing of stunting rates in (b) also indicates that these districts, with the exception of the Central Gonja district, still have high prevalence of stunting – just like their neighbours.

Table 7: District level LISA of stunting rates

UNADJUSTED STUNTING RATES	ADJUSTED STUNTING BY EMPIRICAL BAYES-BASED SMOOTHING



(a)



(b)

UNADJUSTED STUNTING RATES		ADJUSTED STUNTING BY EMPIRICAL BAYES-BASED SMOOTHING	
High-high	Low-low	High-high	Low-low
Chereponi(NR)***	Dormaa East(BA)*	Chereponi(NR)***	Techiman Mun (BA)*
Karaga(NR)***	Afram Plains South(ER)**	Karaga(NR)**	South Dayi (VR)*
Gushiegu(NR)***	Ho West (VR)*	Gushiegu(NR)**	East Akim Mun (ER)*
Savelugu Nanton(NR)*	South Dayi(VR)*	Savelugu Nanton(NR)*	New Juabeng Mun(ER)**
Saboba(NR)***	Atwima Mponua(AS)*	Saboba(NR)**	Suhum Mun (ER)*
Mion(NR)***	Amansie West(AS)*	Mion***	Akuapim North (ER)**
Sagnarigu*	New Juabeng Mun.(ER)*	Sagnarigu*	Shai Osudoku (GA)*
Zabzugu**	Akwapim North (ER)**	Zabzugu**	Ayensuano(ER)*
Tamale Metro**	Ayensuano (ER)*	Tamale Metro(NR)*	Ada East (GA)*
Cental Gonja*	Ada East (GA)*	East Gonja**	Akuapim South (ER)**
East Gonja**	Akuapim South (ER)**	Nanumba North***	Ningo Prampram*
Nanumba North***	Adentan Mun(GA)**	Nanumba South**	Adentan Mun(GA)*
Nanumba South*	Kpone Katamanso (GA)**	Kpandai*	Kpone Katamanso (GA)***
Kpandai*	La Nkwantanang /Madina (GA)*	Krachi Nchumuru(VR)	Ga South Municipal (GA)**
Nkwanta South(VR)*	Ga South Municipal (GA)*	Jomoro (WR)*	Ga West Municipal (GA)*
Krachi Nchumuru(VR)*	Ga West Municipal (GA)*	Yendi Municipal (NR)**	Accra Metro*
Yendi Municipal (NR)**	Ga East Municipal(GA)*	Nkwanta South*	Ashiaman Municipal*
	Kumahu (AS)**		
	Ahafo Ano South (AS)*		
	Ashaiman Municipal(GA)*		
Global Moran I = 0.42***		Global Moran I = 0.24***	

*P-values *<0.05 **<0.01 ***0.001; NR is Northern Region; GA, Greater Accra; VR, Volta Region; WR, Western Region; ER, Eastern Region; AS, Ashanti Region, BA, Brong Ahafo*

Source: Agyen (2020)

The overall pattern depicts a cluster of high stunting rates in the north eastern part of the country, and a cluster of low rates of stunting in some part of the south. Put in context, this is not surprising, since most of the districts in the north eastern part of the country are predominantly rural, while those in the south are urban.

Table 8 gives Global Moran’s autocorrelation coefficients between stunting rates and each explanatory variable. All Moran's coefficients are significant at $p < 0.001$. From the table, the spatial autocorrelation with regards to the two main policy variables – mother’s education and household poverty are relatively high. The positive autocorrelation of the proportion of poor households however, shows that the distribution of higher and lower proportions of poor households is more spatially clustered, with higher rates and lower rates of stunting respectively, than would be expected if the underlying spatial processes were random. On the other hand, the negative index of mother’s education reflects a dispersed pattern. It shows that proportion of higher schooling years of mothers “repels” higher rates of stunting. Thus, higher rates of mother’s education are adjacent to lower rates of stunting.

Table 8: Moran's indices of explanatory variables

VARIABLE	MORAN INDEX
Proportion of Poor households	0.102
Mother's Education	-0.1
Proportion of children living in rural areas	0.04
Children who had fever	0.005
Size at birth	0.02
No improved water source	0.005
No easy access to health centre	0.079
Children who had diarrhoea	0.005
Proportion Akan	0.04
Proportion Ga	-0.1
Proportion Dagbani	0.067

Source: Agyen (2020)

The regression results of the maximum likelihood estimations of the OLS, SAR and SEM are presented in **Table 9**. The table presents the estimates from these models with their respective model fits. In both the spatial lag model and the spatial error model, the AIC of -197.0 and -199.4 respectively improves over the standard OLS and the R^2s also show an improvement of 27 per cent for both models. The SEM, however, indicates the best fit among the three models. The spatial lag confirms a strong and positive spatial effect coefficient ($\rho = 0.194,\ p < 0.05$). It is statistically significant and shows a lesser spatial autocorrelation in residuals (Moran = 0.013, p < 0.001) than that of the OLS ($\text{Moran} = 0.252,\ p < 0.05$). Intuitively, the results suggest that the effect of adjacent neighbourhood districts for stunting is 19 per cent as large as it is in the focal district. The spatial error effect ($\lambda = 0.229, p < 0.05$) is also statistically significant, indicating that there are some spatially structured unobserved variables that affect stunting at the district level. The

SEM shows that spatial autocorrelation in residuals (Moran's I = 0.004, $p < 0.001$) is smaller compared to the SAR, and is approaching randomness.

Table 9: Results for OLS SAR and SEM

Explanatory variables	OLS estimate	Spatial lag estimate	Spatial error estimate
Proportion of poor households	0.205*** (0.041)	0.198*** (0.039)	0.201*** (0.040)
Mother's education	-0.010* (0.005)	-0.009⁺ (0.005)	-0.010* (0.005)
Proportion of children living in rural areas	0.101* (0.039)	0.099** (0.037)	0.099** (0.037)
Children who had fever	0.152⁺ (0.084)	0.157⁺ (0.081)	0.173* (0.081)
Size at birth	-0.008 (0.015)	-0.008 (0.015)	-0.010 (0.015)
No improved water source	0.069⁺ (0.041)	0.065⁺ (0.39)	0.076⁺ (0.040)
No easy access to health centre	0.011 (0.021)	0.007 (0.020)	0.004 (0.021)
Children who had diarrhoea	-0.093 (0.080)	-0.100 (0.076)	-0.100 (0.076)
Proportion Akan	0.077* (0.036)	0.077* (0.035)	0.083* (0.039)
Proportion Ga	-0.029 (0.062)	-0.016 (0.060)	-0.014 (0.065)
Proportion Dagbani	-0.035 (0.042)	-0.034 (0.040)	-0.034 (0.044)
Spatial effects			
Spatial lag (ρ)		0.194* (0.090)	
Spatial error (λ)			0.229* (0.097)
N	216	216	216
R^2	0.245	0.266	0.269
AIC	-194.77	-197.0	-199.4
Log likelihood	109.4	111.5	111.7
Moran I (error)	0.252	0.013	0.004

*Standard Error presented in parenthesis; ⁺p<0.1; *p<0.05; **p<0.01; ***p<0.001; AIC = Akaike information criterion*

Source: Agyen (2020)

Both SAR and SEM show that districts with higher proportions of poor households, greater number of children living in rural areas and no improved water source have higher proportions of stunted children, – indicating poorer health statuses in children. Mother's education was also found to be significant. The results show that higher mother's years of schooling reduce the rate of stunting.

The local indicator for spatial association results for the residuals of the models are presented in Figure 12. Figure 12a presents the LISA cluster map for the OLS model, while Figure 12b and Figure 12c present that of the SAR and the SEM models respectively.

After controlling for the proportion of poor households, mother's education, residence, water sources, ethnicity and access to health centre, among other key variables, the OLS still show significant spatial autocorrelation. Eleven districts with high prevalence of stunting are clustered at the north eastern part of the country. Figure 12a shows ten districts with low prevalence of stunting adjacent to neighbouring districts with low prevalence, suggesting a positive autocorrelation. Pockets of negative spatial autocorrelation were also observed, with four districts showing a "low-high" and five districts, a "high-high". Relative to the OLS result, the residual map of the SAR in Figure 12b shows only one district with a "high-high", two districts with a "low-low" and one district with a "high-low". The SEM residual map in Figure 12c equally shows less clustering compared to the OLS. The map show 212 districts with no spatial autocorrelation, 2 districts with a positive spatial autocorrelation and 2 others with a negative autocorrelation.

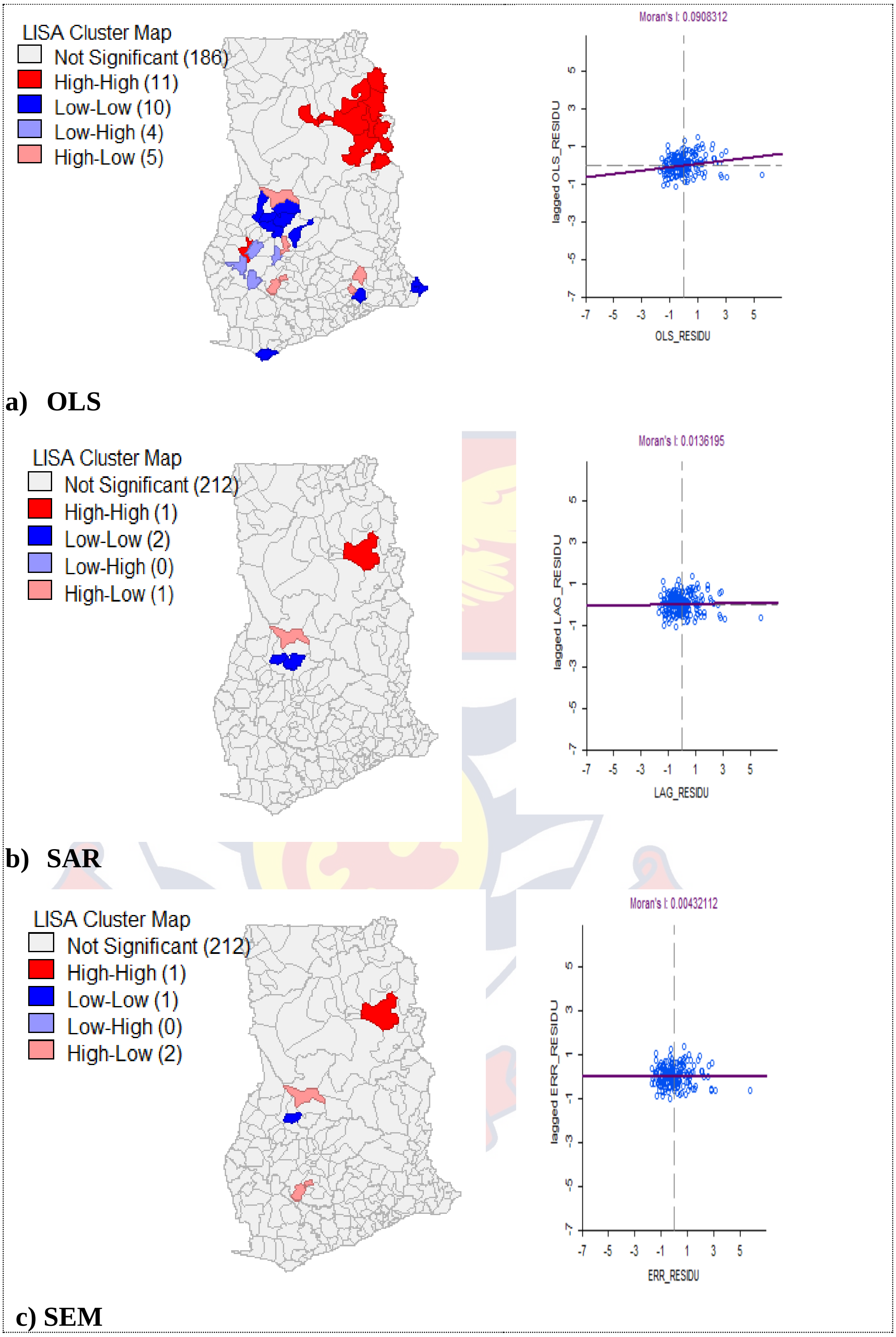


Figure 12: LISA maps of residual errors of models

Source: Agyen (2020)

Effects of Neighbourhood Mothers' Education on Child Health

The previous section shows the significant effect of neighbouring attributes on stunting rates. Among the factors studied, the proportion of poor households and mothers' education had the highest and most significant spatial autocorrelation. This section examines the hypothesis that chronic malnutrition rates significantly fall if the number of years of neighbouring mothers' education increases.

LISA cluster maps of mother's education and bivariate LISA of stunting rates and mother's education are presented in Figure **13**. Across the 216 districts, there are clusters of lower averages of mothers' years of schooling (Figure 13a) in the north eastern parts of the country, indicating that mothers here are less educated compared to those in the rest of the country.

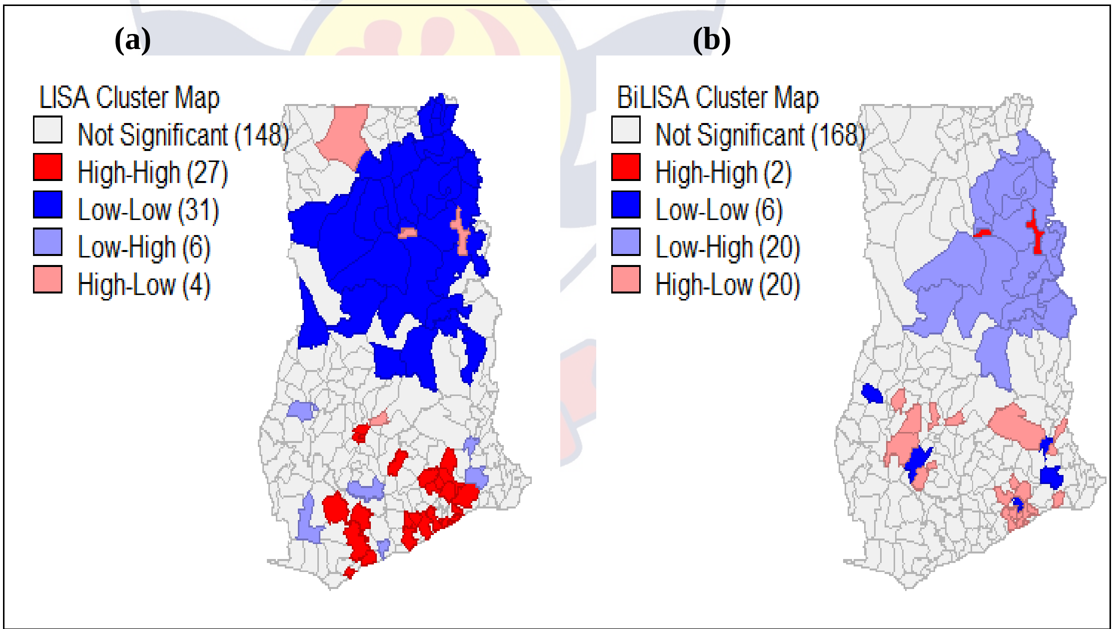


Figure 13: LISA maps of a) mother's education and b) bivariate LISA of neighbouring mother's education and stunting

Source: Agyen (2020)

In contrast, communities where mothers have more years of schooling are clustered in some parts of the south. The Bi-LISA (Figure 13b) shows a negative relationship between neighbouring mothers' education and stunting indicating an improved health status where neighbouring mothers have undergone more years of schooling.

Table 10 shows results for the effect of neighbouring mothers' education and own mothers' education on stunting in children. As indicated in the methodology, neighbouring mothers' years of schooling is captured by the spatial weights of mothers' years of schooling. The local sociability explanation from Bernard et al. (2007b) drove the choice of this variable. The concept explicates the idea where people are able to improve their health from the knowledge of others through communication and community organisations to help improve their health. The association between neighbouring mothers' years of schooling and stunting is significant at the cluster and the district-level. This is an indication that neighbouring mothers' years of schooling are important in explaining the stunting rate, and thus that more years of education among neighbouring mothers' reduces stunting in children.

We also observe that an increase in own mothers' years of schooling improves child health. The proportion of children living in rural areas, access to health centre, lack of improved sanitation and the wealth status of households also significantly affects stunting in children. Table 10 shows that, rural clusters and districts are associated with high rates of stunting. Clusters with a higher proportion of households that have difficulty accessing a health centre, had high stunting prevalence rates. The results also show that stunting prevalence decreases with wealth; that is, higher district and clusters average wealth score reduces stunting rates.

Table 10: Effect of neighbourhood mother's education on stunting in Ghana

	Models	
Explanatory variables	SLX (Cluster-level)	SLX (District- – level)
	(Coeff)	(Coeff)
Neighbourhood mother's	-0.092**	-0.165**
Education	(0.033)	(0.075)
Mother's education	-0.065**	-0.218***
	(0.023)	(0.055)
Proportion of children living in	0.135***	0.165***
rural areas	(0.019)	(0.027)
Proportion of children under 5 in	0.099	0.417
the household	(0.127)	(0.316)
No easy access to health centre	0.112***	0.907
	(0.024)	(0.555)
No improved sanitation	0.512**	0.927^{+}
	(0.195)	(0.496)
No improved water source	0.196	1.192*
	(0.168)	(0.471)
Proportion of people with	-0.388^{+}	-0.078
insurance	(0.205)	(0.053)
Average wealth score	-0.426*	-1.085*
	(0.192)	(0.503)
Proportion of male children	0.148***	0.231***
	(0.035)	(0.026)
Children who had fever	-0.009	-0.052
	(0.305)	(0.895)
N	423	216
R^2	0.555	0.629
AIC	1350.78	878.91
Log Likelihood	-663.392	-427.46

Standard Error presented in parenthesis; $^{+}p<0.1$; $*p<0.05$; $**p<0.01$; $***p<0.001$; AIC = Akaike information criterion

Source: Agyen (2020)

Finally, the table also shows that higher proportions of male children in an area increase the prevalence of stunting in that area. This could be attributed to biological factors associated with male children compared to females (Bork & Diallo, 2017; Wamani et al., 2007).

Discussion

The study set out to examine spatial dependence of stunting in children in Ghana. The data only allowed for the analysis at the cluster and district level. The study also examined the effects of neighbouring mothers' education on stunting prevalence also at the district- and cluster-levels. The study found that although substantial spatial clustering could be attributed to differences in the factors that drive stunting, a significant margin of spatial clustering still remained in the residuals of the ordinary least squares. The SAR and SEM best accounted for the clustering indicating that stunting and its attributed factors of neighbouring districts and clusters affect stunting prevalence for a particular district or cluster. Generally, districts with high prevalence of stunting are clustered in the north-eastern part of Ghana and low prevalence in some parts of the south. This clearly gives an indication of a spill over effect and called for a spatial analysis of the correlates of stunting.

For the variable, mothers' education, the study found a significant spatial clustering. Low levels of mothers' education in the areas with high prevalence of stunting. An investigation of the effect of neighbouring mother's education showed a significant effect on adjoining districts and clusters. This suggests that higher rates of neighbouring mothers' education affect the rates of stunting in a specific district or cluster negatively. This could possibly be explained by the concept of social networks in the structuration theory.

Through social networks mothers may interact and learn from each other including best practices in taking care of their children. These interactions are sometimes aided by the structure of the society or institutions for education and healthcare which are not restricted to residents of a particular district or cluster. This brings to bare the importance of social attributes in addition to individual-level attributes of child stunting.

Chapter Summary

This chapter has presented findings and discussion on the study into clustering of stunting in Ghana, the effect of neighbourhood characteristics on stunting, and the effect of neighbouring mothers' education on stunting. Results from the first hypothesis suggest stunting is clustered across some districts in Ghana. Some districts in the north eastern part of the country showed similar attributes of high stunting prevalence, indicating a propensity for nearby locations to influence each other. However, lower stunting prevalence was clustered in some parts of southern Ghana, also showing spatial dependence. The second hypothesis – estimated by spatial lag regression and spatial error regression – also indicated that the presence of spatial dependence in stunting is explained by behavioural diffusion as a result of interaction and shared attributes at neighbouring locations (attributional dependence). The third hypothesis, estimated by a spatial cross-regressive model showed that neighbouring mothers' years of education reduce stunting rates.

CHAPTER SIX

A STRUCTURAL EQUATION MODELLING APPROACH TO EXAMINING THE EFFECT OF NEIGHBOURHOODS ON CHILD HEALTH

Introduction

This chapter attempts to explore spatial dependence on child health at the individual level, in the absence of unique geographical coordinates of individual children. The chapter employs structural equation modelling to estimate a more complex system of relationships and mediated effects on child health. Although it is equally based on the theories and concepts of structuration, externalities and social capital, this chapter draws more on the intersectionality theory, which provides a lens for allowing intersectional associations of the determinants of child health. Specifically, the chapter tests that (1) Type of residence, neighbours' wealth, neighbouring mothers' education, distance to health centre, sanitation, and water sources are indicators of neighbourhood or spatial effects; (2) socioeconomically advantaged neighbourhoods improve child health; and (3) the relationship between neighbouring mothers' education and child health is moderated by own mother's education.

Methodologically, the chapter builds on identified weaknesses inherent in the use of our dataset for examining individual-level spatial dependence. The DHS data limitation in this regard relates to the absence of unique geographical coordinates for individual respondents or households used to create weights when examining spatial dependence and inequalities. The chapter defies this snag and adopts Folmer and Oud's (2008) approach by using a latent variable to represent spatial dependence – of which some household- and cluster-level variables are observed variables.

Confirmatory factor analysis was used to test the hypothesis of the existence of a relationship between the observed variables (type of residence, neighbours' wealth, neighbouring mothers' education, distance to health centre, improved water source and improved sanitation) and the underlying latent construct, spatial dependence. The measurement model in Figure 9, therefore, tests the hypothesis that spatial dependence explains the common variation among the observed variables.

Empirical Results

First, the section presents unstandardized and standardized estimates for two main anthropometric measures Height-for-age (HAZ) and weight-for-age (WAZ). The indirect and total effects of various mediations tested in the model are then presented. The results of the structural equation modelling of spatial dependence on child anthropometric indicators are presented in Table 11. Unstandardized results for HAZ and WAZ are presented in Appendix L and Appendix M respectively, whiles standardized results are reported in Figure 14 and Figure 15.

Type of Residence, Neighbours' Wealth, Neighbouring Mothers' Education, Distance to Health Centre, Sanitation, and Water Sources as Indicators of Neighbourhood or Spatial Effects

Confirmatory factor analysis was conducted to test the hypothesis that the six-factor items are associated with the latent variable. The result is shown in the measurement model in Table 11. It is evident that the hypothesized factors for spatial dependence (type of residence, neighbours' wealth, neighbouring mothers' education, distance to health centre, improved sanitation and improved water sources) are good indicators of the underlying construct. This is observed in all the models (for both HAZ and WAZ). Manifestly, it is observed in the standardized results, which show good factor loadings in the representation of spatial dependence. Figure 14 and Figure 15 show that neighbouring mothers' education and neighbours' wealth status have considerably strong associations with the latent variable, spatial effect, with factor loadings of 0.76 and 0.91 respectively. Residence (whether urban or rural) and improved water source also show good loadings of 0.72 and 0.65 respectively in representation of spatial effect. Although distance to health centre and sanitation demonstrate quite weak correlations with spatial effect, the factor loadings of 0.296 and 0.283 respectively are significant at 1 per cent p-value. All these variables appear to indicate the overall vantage in a neighbourhood.

Neighbourhood Socioeconomic Effects on Child Health

The second hypothesis for this chapter addresses the direct and indirect effects of spatial effects or neighbourhood socioeconomic factors on child health outcomes. The study found a significant positive association of spatial effects on child health. With regards to the HAZ ($\beta = 0.092$, $p < .001$) and WAZ ($\beta = 0.069$, $p < .001$). This shows that residing in a socioeconomically advantaged neighbourhood improves a child's health. This finding is consistent with Quansah et al. (2016), who found that social factors such as residence disparities (rural or urban) affect child mortality, nutritional status and health seeking-behaviour.

Table 11: Estimates of measures of child health outcomes (HAZ and WAZ) from the structural equation model

	HAZ		WAZ	
Structural	Unstandardized	Standardized	Unstandardized	Standardized
HAZ/WAZ ←				
Mother's BMI	0.248*** (0.052)	0.109*** (0.023)	0.289*** (0.041)	0.155*** (0.022)
Mother's education	0.019** (0.006)	0.066** (0.021)	0.017** (0.005)	0.073** (0.021)
Spatial effect	0.336*** (0.086)	0.092*** (0.023)	0.206** (0.071)	0.069** (0.024)
Child male	-0.117** (0.044)	-0.045** (0.017)	-0.034 (0.037)	-0.016 (0.017)
Size at birth	0.296*** (0.047)	0.116*** (0.018)	0.357*** (0.039)	0.170*** (0.018)
Birth interval	0.000 (0.001)	0.003 (0.021)	-0.000 (0.001)	-0.013 (0.021)
Child age	-0.018*** (0.001)	-0.236*** (0.018)	-0.007*** (0.001)	-0.106*** (0.018)
Mother's age	0.008+ (0.004)	0.043+ (0.023)	0.008* (0.004)	0.054* (0.023)
Mother's marital status	-0.060 (0.061)	-0.019 (0.019)	-0.075 (0.051)	-0.029 (0.020)
Children below 5 in household	-0.063* (0.028)	-0.044* (0.020)	-0.040+ (0.023)	-0.033+ (0.019)
Age of household head	-0.003 (0.002)	-0.026 (0.020)	-0.003 (0.002)	-0.031 (0.019)
Mother's BMI←				
Spatial effect	0.633*** (0.035)	0.395*** (0.018)	0.633*** (0.035)	0.395*** (0.018)
Mothers age	0.010*** (0.002)	0.122*** (0.019)	0.010*** (0.002)	0.121*** (0.019)
Mother's education←				
Neighbouring mothers' education	1.773*** (0.027)	0.430*** (0.020)	1.773*** (0.027)	0.431*** (0.020)
Neighbouring mothers' education←				
Spatial effect	2.371*** (0.064)	0.755*** (0.011)	2.371*** (0.064)	0.756*** (0.011)
Household Wealth status←				
Mother's education	0.073*** (0.006)	0.244*** (0.024)	0.073*** (0.006)	0.244*** (0.024)
Children below 5years in house	-0.297*** (0.027)	-0.193*** (0.017)	-0.297*** (0.027)	-0.193*** (0.017)

Table 11, Continued

	HAZ		WAZ	
Spatial effect ←				
Household wealth status	0.235*** (0.005)	0.913*** (0.008)	0.235*** (0.005)	0.912*** (0.008)
Measurement				
Residence ← spatial effect	1(Constrained)	0.724*** (0.013)	1(Constrained)	0.725*** (0.012)
Distance to health centre ← Spatial effect	0.387*** (0.026)	0.296*** (0.018)	0.387*** (0.026)	0.296*** (0.018)
Source of drinking water ← Spatial effect	0.802*** (0.029)	0.654*** (0.014)	0.802*** (0.029)	0.654*** (0.014)
sanitation ← Spatial effect	0.392*** (0.028)	0.283*** (0.019)	0.392*** (0.028)	0.283*** (0.019)
Neighbouring households' wealth status ← Spatial effect	3.313*** (0.066)	0.910*** (0.008)	3.314*** (0.066)	0.912*** (0.008)
Covariance of residuals for residence and neighbouring households' wealth status	0.032*** (0.007)	0.188*** (0.032)	0.031*** (0.007)	0.186*** (0.033)
Covariance of residuals for residence and neighbouring mothers' education	-0.017** (0.006)	-0.078** (0.028)	-0.018** (0.006)	-0.079** (0.028)
Covariance of residuals for neighbouring household wealth status and neighbouring mothers' education	0.161*** (0.016)	0.479*** (0.025)	0.159*** (0.016)	0.477*** (0.025)
Goodness-of-fit				
RMSEA	0.048<0.05		0.048	
CFI	0.943		0.944	
TLI	0.929		0.929	
Stability index	0.516		0.519	
N	2,714		2714	

Standard Error presented in parenthesis; $^{+}p<0.1$; $*p<0.05$; $**p<0.01$; $***p<0.001$; RMSEA is Root Mean Squared Error of Approximation: CFI = Comparative Fit Model; TLI=Tucker-Lewis Index

Source: Agyen (2020)

Other Correlates of Child Health

The study considered several categories of correlates of child health in addition to the neighbourhood characteristics. These included maternal components, child-level characteristics and household characteristics.

Estimates from the path diagram presented in Table 11 show that a child's own mother's education affects the child positively (HAZ: $\beta = 0.019$, $p < 0.01$; WAZ: ($\beta = 0.073$, $p < 0.01$). This indicates that mothers with higher education are more likely to have children with good health. In a developed world context, Güneş (2015) found that a mother's completion of primary school resulted in earlier preventive care initiation and good health care behaviour, leading to improved child health. In the Ghanaian context, Frempong and Annim, (2017) observed that mothers who have a primary, middle or senior secondary education are more likely to feed their children with more diversified foods which improve their health.

In addition to mother's education, other key maternal factors include the mother's BMI and age. The results show that mother's BMI significantly correlates with HAZ ($\beta = 0.248$, $p < 0.001$) and WAZ ($\beta = 0.289$, $p < 0.001$). This is consistent with the findings of Tigga and Sen (2016) and indicative of a strong genetic drive relating maternal and child anthropometry. The age of the mother shows a direct positively significant effect on child health (HAZ: $\beta = 0.008$, $p < 0.1$; WAZ: $\beta = 0.008$, $p < 0.05$). This supports the argument by UNICEF (2010) that children of younger mothers are more likely to have ill-health, be stunted or even die.

With regard to the child-specific characteristics, a significantly negative relationship is observed between the age of the child and the child's health. The unstandardized HAZ and WAZ models show coefficients (β = -0.018, $p < 0.001$) and (β = -0.007, $p < 0.001$) respectively. It implies that additional age of under-5 children increases their risk to poor health. Another significant child-specific variable is the sex of the child. The results show a negative relationship between the male child and height-for-age. With β = -0.117 and $p < 0.01$ for the unstandardized model, it suggests that a male child may have a lower HAZ score and be more likely to be stunted compared to a female. The size of the child at birth also shows a positively significant effect on both HAZ and WAZ. This is corroborated by several studies, including the results of Bork and Diallo (2017), who found that in Senegal, male children had lower HAZ than females. The effect could be attributed to biological differences between males and females in the early stages of life (Cronk, 1989; Garenne, 2003).

At the household level, the study examined the effect of the number of children below 5 in a household on child health. It is observed that more children in a household reduces a child's HAZ and WAZ scores. This finding corroborates Darteh et al.'s (2014) study, which observed that children from households with between five and eight children are more likely to be stunted compared to those between one and four children. This could be explained by the ineluctable strain on household resources resulting from high consumption (Adewara & Visser, 2011; Giroux, 2008).

Neighbouring Mothers' Education

The study tests the hypothesis that the effect of neighbouring mothers' years of education is moderated by a child's own mother's education. The path linking neighbouring mother's education and mother's education was significant. The coefficients (unstandardized: β = 1.773, $p < 0.001$; standardized: β = 0.430, $p < 0.001$) suggest that women found in neighbourhoods that have higher education levels of other women are more likely to have higher education too. This could be attributed to healthy competition and the urge to fit in. Such mothers are often able to exchange information and share ideas which ultimately improves their livelihoods and their children's health (Byrnes et al., 2011). The effect of neighbouring mother's education, in this case, is deemed to indirectly affect child health status.

With regards to the relationship between neighbouring mothers' years of education and child health, the results show that children have better health (higher HAZ and WAZ scores) when they reside in neighbourhoods with high education among mothers other than their own. The indirect coefficients (HAZ: β = 0.052, $p < 0.001$; WAZ: β = 0.045, $p < 0.001$) were significant.

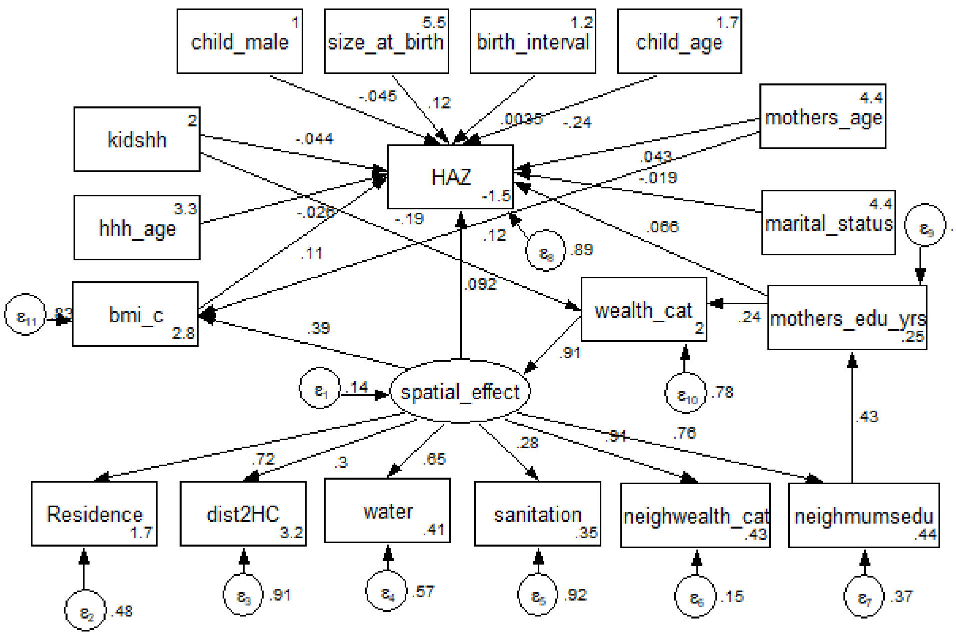


Figure 14: Standardized estimates of child health outcome (HAZ) from the structural equation model

Source: Agyen (2020)

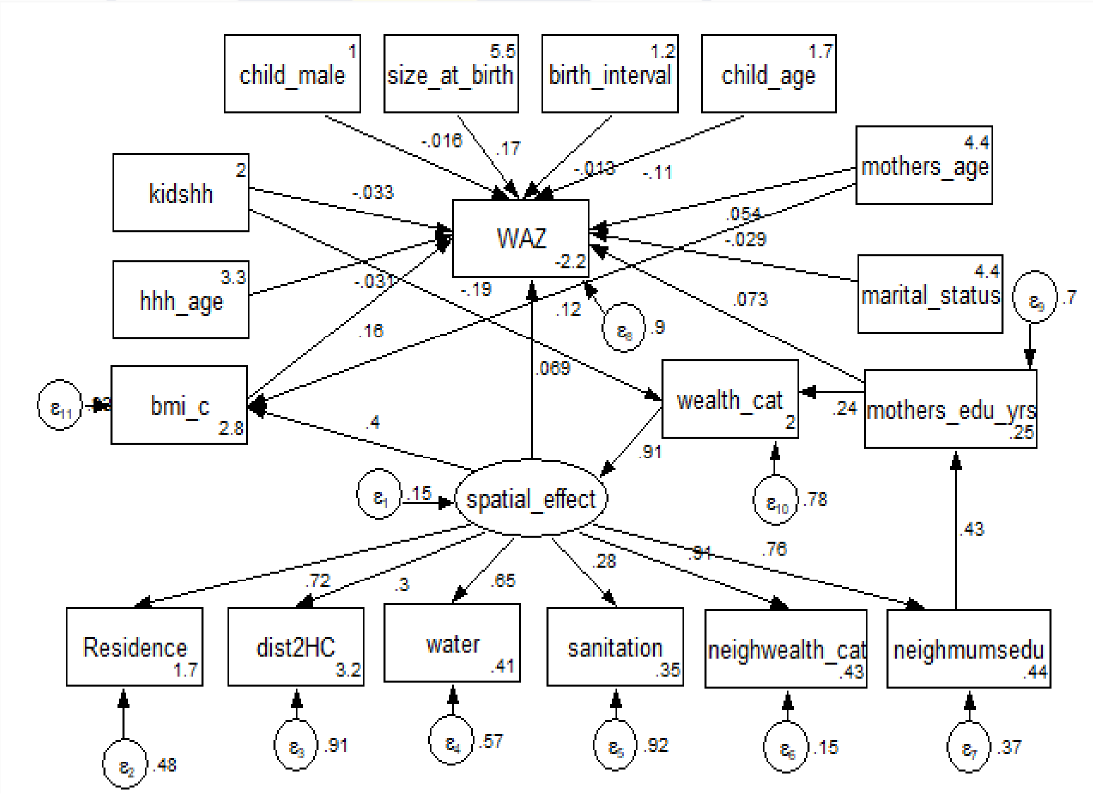


Figure 15: Standardized estimates of child health outcome (WAZ) from the structural equation model

Source: Agyen (2020)

Other Path Analysis and Mediating Effects on Child Health

The study sets out to examine the drivers of child health as a system where factors drive child health through a causal complexity of multiple paths. These pathways and factors are adapted from the CSDH conceptual framework (WHO, 2010a) on the social determinants of health, underlined with the concept of intersectionality.

Mother's BMI ← Mother's Age

Unstandardized results in Table 11 shows that the effect of a mother's age on the nutritional status of her child is partly mediated by the mother's BMI. For both HAZ and WAZ models, mother's age significantly correlates mother's BMI (HAZ: $\beta = 0.010$, $p < 0.001$; WAZ: $\beta = 0.010$, $p < 0.001$). The correlation between mother's BMI and mother's age could be attributed to the fact that many people, especially women, tend to have decreasing lipid turnover with age. As mothers grow older, the rate at which lipids (fats) in the fat tissue or cells is excreted is slower, as they are increasingly stored (Karolinska Institutet, 2019).

Mother's BMI ← Spatial Effect

In each of the HAZ and WAZ models, the study simultaneously tests the hypothesis that mother's BMI is influenced by locational effect. This is premised on the findings of Dake (2012), which found spatial variation in the BMI of women in Ghana. The author indicated that overweight and obese women are clustered in some parts of the country, which could be attributed to locational and environmental factors that encourage high caloric intake and discourage physical activity.

The present study found that, for both standardized models (HAZ: $\beta = 0.633$, $p < 0.001$; WAZ: $\beta = 0.633$, $p < 0.001$) the location of mothers influenced their BMI.

Household Wealth Status ← Number of Children Below 5 Years in Household

Given that increases in household size are associated with poverty as a result of increased household expenditure which eventually affects child health (Gang et al., 2002), the study tested the hypothesis that increasing numbers of under-5 children in a household reduces household wealth. The results show that in both models the number of under-5 children in a household negatively affects household wealth (HAZ: $\beta = -0.297$, $p < 0.001$; WAZ: $\beta = -0.297$, $p < 0.001$).

Household Wealth Status ← Mother's Education

The study concurrently tested the hypothesis that educated mothers are able to contribute to household income. The results show that the HAZ and WAZ models had a significant positive correlation between mother's education and household wealth (HAZ: $\beta = 0.073$, $p < 0.001$; WAZ: $\beta = -0.073$, $p < 0.001$). This result corroborates evidence from Nepal, which found that women's education improves household wealth, hygiene and child nutritional indices (Miller et al., 2017).

Neighbourhood effect ← household wealth

Globally, the rich and poor are clustered in respective areas (Källestål et al., 2019). Most private institutions and some organisations, including schools and hospitals, tend to establish in rich communities or areas, since residents of these areas would be able to afford their services. The rich, on the other hand, prefer to live among other rich neighbours to be able to enjoy these services. As suggested by Florida (2018), the rich moves to certain areas – mostly urban – due to the concentration of high paying professional jobs. They enjoy a cluster of high-end amenities such as cinemas, restaurants, supermarkets and other venues peculiar to these areas.

The present study found that household wealth significantly influences the location and its effect on individuals. The unstandardized models show the coefficients (HAZ: $\beta = -0.235$, $p < 0.001$; WAZ: $\beta = -0.235$, $p < 0.001$).

Indirect and Total Effects

The aforementioned relationships were tested concurrently to extricate and estimate the direct and indirect pathways to child health nutritional status. Table 12 presents the indirect and total effects of the explanatory variables on under-5s' HAZ and WAZ scores. Paths linking child characteristics, maternal factors, household factors and spatial effects on child nutritional outcomes indicate that these factors directly and indirectly affect under-5 nutritional outcomes.

The result shows that neighbouring mothers' education had an indirect effect on nutritional outcome. The path coefficient from neighbouring mothers' education to mother's education was significant. Significant direct and indirect effects of mother's education, mother's age, spatial effects and number of under-5 children in the household were observed (see Table 12).

Table 12: Total effects of the structural model

	HAZ		WAZ	
	Indirect	Total	Indirect	Total
Neighbouring mothers' education	0.052*** (0.002)	0.052*** (0.002)	0.045*** (0.002)	0.045*** (0.002)
Mother's BMI	-	0.248*** (0.052)	-	0.289*** (0.041)
Mother's education	0.011*** (0.001)	0.029*** (0.006)	0.009*** (0.001)	0.025*** (0.005)
Household wealth status	0.144*** (0.003)	0.144*** (0.003)	0.116*** (0.002)	0.116*** (0.002)
Spatial effect	0.279*** (0.010)	0.615*** (0.087)	0.290*** (0.011)	0.496*** (0.072)
Child male	-	-0.117** (0.044)	-	-0.034 (0.037)
Size at birth	-	0.296*** (0.047)	-	0.357*** (0.039)
Birth interval	-	0.000 (0.001)	-	-0.000 (0.001)
Child age	-	-0.018*** (0.001)	-	-0.007*** (0.001)
Mother's age	0.002*** (0.001)	0.011* (0.004)	0.003*** (0.001)	0.011** (0.004)
Mother's marital status	-	-0.060 (0.061)	-	-0.075 (0.051)
Children below 5years in household	- 0.043*** (0.007)	-0.106*** (0.028)	-0.035*** (0.005)	-0.74** (0.023)
Age of household head	-	-0.003 (0.002)	-	-0.003 (0.002)

Source: Agyen (2020)

Model Fit

With regards to the assessment of the goodness of fit, the results reveal that the model is a good fit to the data with comparative fit index (CFI) = 0.943; root mean square error of approximation (RMSEA) = 0.048, and Tucker-Lewis Index (TLI) = 0.929. Given the fit recommendations outlined by Hu and Bentler (1999), the measurement model and structural model is considered good enough for the data.

Stability indices, 0.516 for the HAZ model and 0.519 for the WAZ model are less than 1. This implies that the reported estimates yield a stable model.

Chapter Summary

The determinants of child nutritional outcomes have been well researched. However, these studies have concentrated on individual, household and maternal factors. The effect of these variables on child nutritional status has been looked at as sums of these variables. The present study used structural equation modelling to disentangle the total effects of the determinants of child health to direct and indirect effects in a multi-faceted system of equations. Two models, one for HAZ and the other for WAZ were tested. Part of the models (the measurement model) was used to test the type of residence, neighbours' wealth, neighbouring mothers' education, distance to a health centre, improved water source and improved sanitation as indicators of spatial effects. The study found that spatial variations or neighbourhood effects significantly underlie these observed variables.

The study also found that children residing in advantaged neighbourhoods (neighbourhoods with wealthy neighbours, mothers' with higher years of education, no problems accessing or in close proximity to health centres, improved water source, improved sanitation and urban areas) have better health statuses than those living in disadvantaged neighbourhoods. Neighbourhood wealth status was the most influential indicator of neighbourhood effects, followed by neighbouring mothers' education and residence (rural or urban), respectively. Finally, mother's education was found to mediate the relationship between neighbouring mothers' education and child nutritional status. Each of the models tested had a good fit and showed the importance of spatial variations or neighbourhood effects in modelling child health outcomes.

CHAPTER SEVEN

MULTILEVEL AND SPATIAL ANALYSIS OF CHILD HEALTH: A SUB-SAHARAN AFRICA CONTEXT

Introduction

This chapter provides an empirical analysis of the risk factors associated with child health in Sub-Saharan Africa, and the assessment of the neighbourhood effects or disparities of some key correlates on stunting. The main hypothesis is that the neighbourhood effect of the correlates of stunting are not homogenous. More specifically, this chapter tests the hypotheses that: (1) mothers' with secondary and higher education in a neighbourhood significantly improves a child's health over and above the child's own mother's education. (2) the effect of the proportion of mothers' education on stunting varies across neighbourhoods, and (3) the effect of improved water on stunting varies across neighbourhoods. The chapter uses data from 30 Sub-Saharan African countries on both spatial, fixed effects and random effect models to address the objectives. The next section presents the descriptive analysis of child health outcomes and individual, household and neighbourhood characteristics.

Descriptive Findings

Table 13 presents the results of the bivariate analysis, testing the association between the independent variables and health outcomes. The results show that 14.64 per cent of children below 6 months are stunted as compared to 17.09 per cent of children from 6 to 8 months old, 23.44 per cent of children from 9 to 11 months old and 33.10 per cent of children from 12 to 17 months old. Out of 21,143 children aged 18 to 23 months, 44.27 per cent are stunted, which is lower than the percentage of stunted children aged 24 to 35 months, 36 to 47 months, and 48 to 59 months – thus, recording 45.28 per cent, 41.36 per cent and 35.71 per cent respectively. These show statistically significant differences in the prevalence of stunting across the different age groups. The same can be said for the prevalence of wasting. Most importantly, it is observed that the proportion of stunted children increases with age up to 35 months and then falls. The proportion of wasted children on the other hand, also increases up to 11 months, falls up to 47 months and increases again, suggesting a non-linear relationship between child age and child health outcomes.

The results also show that the proportion of stunted male children is higher than females. Approximately 48 per cent of male children are stunted, while about 33 per cent of female children are stunted. Also, 9.2 per cent of male children are wasted compared to 7.73 per cent of female children. This suggests that male children are more vulnerable than females and this difference could be attributed to differences in biological make-up and possibly some behavioural factors (Cronk, 1989; Garenne, 2003) like dietary discrimination (Leslie et al., 1997).

Table 13: Bivariate analysis for statistical association between the independent variables and child health outcomes (stunting and wasting)

	Stunted		Not stunted		Wasted		Not Wasted	
	%	Number of children	%	Number of children	%	Number of children	%	Number of children
Child age								
<6	14.64	3,207	85.36	18,696	11.77	2,567	88.23	19,235
6-8	17.09	2,152	82.91	10,440	12.51	1,576	87.49	11,017
9-11	23.44	2,779	76.56	9,076	13.55	1,608	86.45	10,262
12-17	33.10	8,238	66.90	16,649	11.79	2,935	88.21	21,959
18-23	44.27	9,360	55.73	11,783	9.28	1,962	90.72	19,180
24-35	45.28	19,550	54.72	23,627	6.77	2,926	93.23	40,266
36-47	41.36	17,881	58.64	25,351	5.75	2,486	94.25	40.772
48-59	35.40	14,550	64.29	26,190	6.19	2,526	93.81	38,261
Chi square		10000.00 (Pr = 0.00)				2200 (Pr = 0.00)		
Sex of child								
Male	37.83	41,687	62.17	68,520	9.20	10,142	90.80	100,090
female	32.96	36,030	67.04	73,292	7.73	8,444	92.27	100,862
Chi square		568.79 Pr = (0.00)				154.19 (Pr = 0.00)		
Size at birth								
Very small	44.38	5,475	55.62	6,863	14.88	1,838	85.12	10,515
Small	42.09	9,080	57.91	12,492	11.05	2,384	88.95	19,184
Average or larger	34.24	59,104	65.76	113,505	7.82	13,506	92.18	159,100
Chi square		948.64 (Pr = 0.00)				918.22 (Pr = 0.00)		

Table 13, continued

	%	No. of children	%	No. of children	%	No. of children	%	No. of children
Mother's education								
No education	41.34	34,914	58.66	49,534	12.28	10,387	87.72	74,167
Primary	36.64	29,849	63.36	51,613	6.13	4,993	93.87	76,447
Secondary	25.60	12,205	74.40	35,470	6.10	2,902	93.90	44,703
Higher	12.54	743	87.46	5,184	5.10	302	94.90	5,620
Chi square		4700 (Pr = 0.00)				2600 (Pr = 0.00)		
Water source								
Not improved	40.62	34,038	59.38	49,759	9.30	7,802	90.70	76,059
Improved	32.18	43,679	67.82	92,053	7.95	10,784	92.05	124,893
Chi square		1600 (Pr = 0.00)				122.83 (Pr = 0.00)		
Sanitation								
Not improved	39.17	54,359	60.83	84,432	9.26	12,856	90.74	125,993
Improved	28.93	23,358	71.07	57,380	7.10	5,730	92.90	74,959
Chi Square		2300 (Pr = 0.00)				306.58 (Pr = 0.00)		
Household wealth								
Poorest	42.31	23,507	57.69	32,054	10.22	5,685	89.78	49,940
Poorer	39.73	18,983	60.27	28,799	8.71	4,161	91.29	43,637
Middle	36.29	15,544	63.71	27,286	8.19	3,506	91.81	39,324
Richer	31.26	12,525	68.74	27,539	7.64	3,056	92.36	36,967
Richest	21.50	7,158	78.50	26,134	6.55	2,178	93.45	31,084
Chi square		4700 (Pr = 0.00)				422.28 (Pr = 0.00)		
Breastfeeding								
Ever breastfed	35.67	72,879	64.33	131,439	8.60	17,566	91.40	186,758
Never breastfed	38.55	1,750	61.45	2,789	8.17	371	91.83	4,171
		16.098 (Pr = 0.00)				1.04 (Pr = 0.308)		

Table 13, continued

	%	No. of children	%	No. of children	%	No. of children	%	No. of children
Residence								
Urban	26.50	16,877	73.50	46,798	7.54	4,801	92.46	58,849
Rural	39.04	60,840	60.96	95,014	8.84	13,785	91.53	200,952
Chi square		3100 (Pr = 0.00)				98.578 (Pr = 0.00)		

Source: Agyen (2020)

On the association between size at birth and child health, the results show that child health varies significantly for the various size categories of children at birth; 44.38 per cent of children who were very small in size at birth are stunted, and about 15 per cent are wasted. Children who were small in size at birth have lower percentages (about 42 per cent for stunting and 11 per cent for wasting). Comparatively, the percentages drop further with children who were average or larger in size at birth. Overall, 34.24 per cent of this group are stunted and 7.82 per cent are wasted.

In the context of the education levels of mothers, significant variations in child health are observed for the respective levels. The proportion of stunted and wasted children tends to be higher for children whose mothers have a lower level of education. Table 13 shows that about 41 per cent and 12.28 per cent of children whose mothers have no educational background are stunted and wasted respectively. These are relatively high compared with children whose mothers have, at most primary education. For these children, 36.64 per cent are stunted, while 6.13 are wasted. With respect to mothers with a secondary level of education, approximately 1 out of every 4 children is stunted, whiles about 6.1 per cent are wasted. Among the various groups of mothers' education levels, the proportions of stunted and wasted children are lowest for those whose mothers have higher education levels. For this group, 12.54 per cent are stunted, while 5.10 per cent are wasted. This suggests that children of mothers with higher levels of education are less susceptible to poor health. This could be attributed to increases in household income as well as literacy, leading to the acquisition and effective consumption of information (Thomas et al., 1991).

The results also show a significant association between the source of drinking water and child health. About 41 per cent of children from households without an improved source of drinking water are stunted and 9.3 per cent are wasted. However, among children from households with an improved source of drinking water, 32.18 per cent are stunted and about 8 per cent are wasted. Similarly, child health tends to have a significant association with sanitation. Approximately 39 per cent of children from households without improved sanitation are found to be stunted, and about 9 per cent are wasted. Of the proportion of children from households with improved sanitation, however, about 29 per cent are stunted and 7.1 per cent are wasted. This trend of association can be attributed to the conception that improved water and sanitation tend to reduce infectious diseases that are linked to poor health (Dangour et al., 2013).

The results also show that wealthier households have children with better health statuses than poorer households. With regards to the various categories of wealth status of households (poorest, poorer, middle, richer and richest), the proportion of stunted children are approximately 42 per cent, 40 per cent, 36 per cent, 31 per cent and 22 per cent respectively. The same association is observed for wasting.

More striking are the differences in the association between place of residence and health status. It is observed that 26.5 per cent of children residing in urban areas are stunted and 7.54 per cent are wasted. Among the proportion living in rural areas, approximately 39 per cent are stunted and 9 per cent are wasted. The finding is consistent with previous studies on Ghana (Frempong & Annim, 2017) and Bangladesh and Nepal (Srinivasan et al., 2013). This could be attributed to the limited endowment in socioeconomic characteristics and poor quality of infrastructure in rural areas (Srinivasan et al., 2013). In addition, the results show a significant association between breastfeeding and stunting. About 36 per cent of breastfed children are stunted, while, approximately 39 per cent of those never breastfed are stunted.

Spatial variation of stunting

The overall prevalence of under-5 stunting is 35.40 per cent. Figure 16 presents the distribution of under-5 Stunting prevalence across administrative districts in Sub-Saharan Africa. The map shows spatial variations with higher prevalence of stunting between 35 per cent and 53 per cent in Mali, Ethiopia, Madagascar and in Central Africa; predominantly, Democratic Republic of Congo and Angola. More striking is the prevalence of stunting above 53 per cent found in pockets of administrative areas in parts of western Africa, Democratic Republic of Congo, Angola, Tanzania and Madagascar (in the Androy, Amoron'I Mania, Haute Matsiatra, Vakinankraratra, Atsinanana and Analanjirofo). This is consistent with the findings of McKenna et al. (2019) which found that the eastern provinces of the Democratic Republic of Congo, mainly, North-Kivu and South-Kivu have the highest prevalence of stunting in the country. It is also consisitent with World Bank and UNICEF (as cited by Weber, 2017), indicating that, Madagascar has one of the highest stunting rates in the world with several areas showing prevalence above 52 per cent. This was also corroborated by similar studies (Rakotomanana et al., 2017) that found higher rates of stunting above 50 per cent in some regions in Madagascar (Androy, Amoron'I Mania, Haute Matsiatra, Vakinankraratra, Atsinanana and Analanjirofo using WHO data).

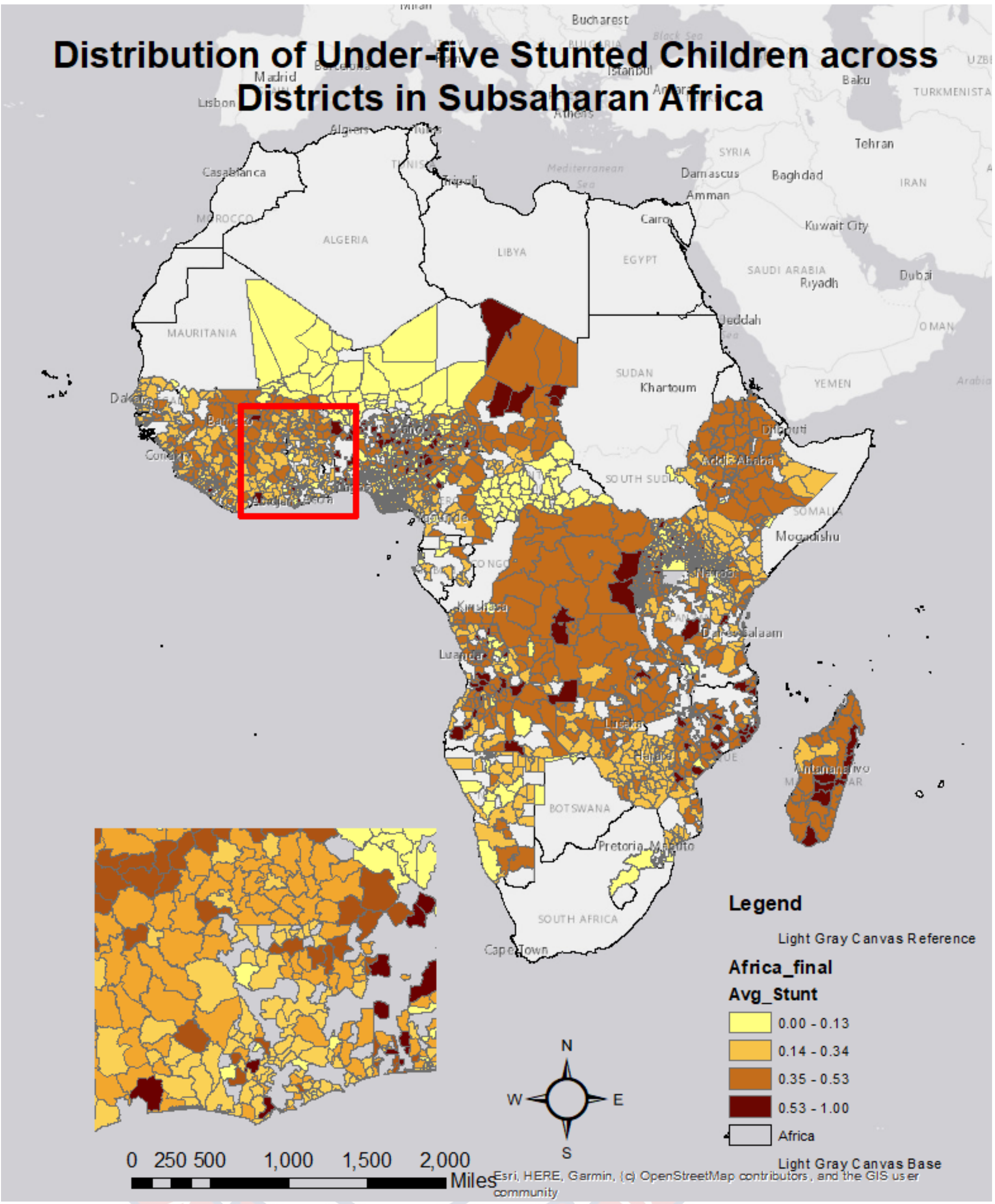


Figure 16: Distribution of under-five Stunting Prevalence across Administrative Districts in Sub-Saharan Africa

Source: Agyen (2020)

Figure 17 shows spatial variation of stunting. The overall global moran I is 0.391, suggesting that, there is an overall pattern of clustering of stunting (see Appendix N). The map shows results on 999 permutations and $p <$ 0.001. The result shows statistically significant spatial autocorrelation between administrative areas. Hot spot clusters are shown in red indicating areas with high stunting rates and are surrounded by equally high stunted areas. The cold spots however, labelled "low-low" show clusters of lower rates of stunting correlating with each other.

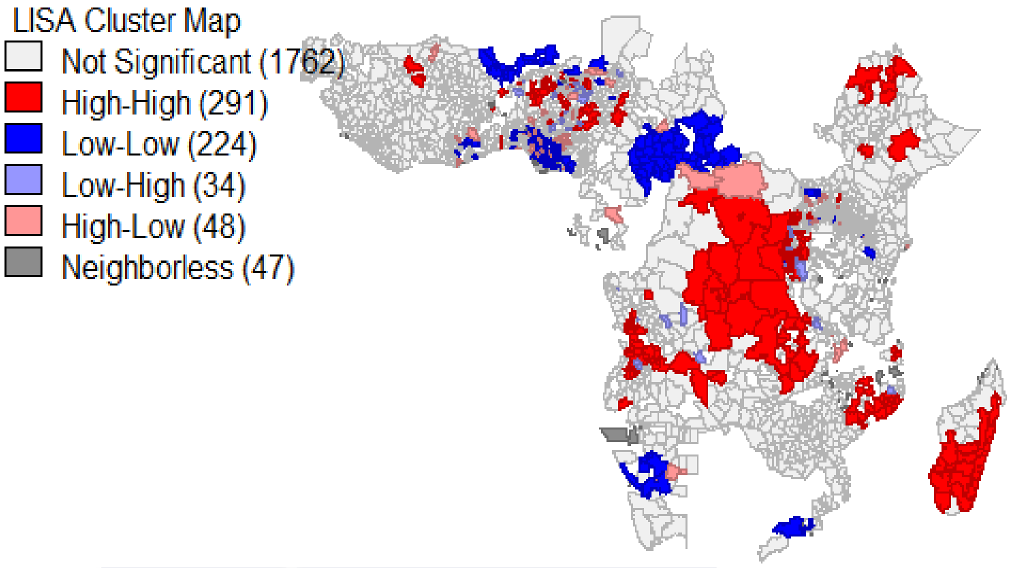


Figure 17: LISA Cluster Map of Stunting in Sub-Saharan Africa

Source: Agyen (2020)

Overall, 515 administrative regions show significant clustering of stunting with similar values. 291 are hot spots and 224 are cold spots. The findings corroborate similar studies which found that residing in some geographic locations pose adverse effect on health outcomes (Adekanmbi et al., 2013; Diez Roux, 2001; Pradhan et al., 2003).

Neighbourhood Effects and Effect of Neighbouring Mothers' Education

The chapter sets out to examine individual and neighbourhood-level factors that influence stunting as an indicator of child health. With emphasis on the contextual effect of neighbourhood mothers' education, data from 30 Sub-Saharan African countries was used to ascertain the role of neighbourhood effects and variations with regards to child health. To this end, the risk of an individual child being stunted was regressed on a set of child-level, maternal, household and neighbourhood predictive variables.

The study use multilevel logistic regression to analyse the factors that drive under-5 stunting at two levels: the individual-level and the community/neighbourhood (cluster) level. The first model, which is empty and without independent variables, is called null/base model (see Appendix P) and presented in Table 14. This shows the extent of community variation on stunting without accounting for any explanatory variable. The result shows a significant variation between neighbourhoods, suggesting that the variation in stunting can be explained by differences between communities or neighbourhoods. Appendix Q provides a caterpillar plot of the neighbourhood effects.

Table 14: Base model for the multilevel estimates for stunting

Base model		
Stunting	Odds ratio	Std. error
Constant	0.498***	0.004
Between neighbourhood variance	0.424***	0.010
Intra-class correlation	0.114	0.002

** p<0.05; **p<0.01; ***p<0.001; Likelihood ratio test statistic =6832.64 with p-value =0.000, testing the null that* $\sigma^2_{uo} = 0$.

Source: Agyen (2020)

The study adjusted for individual and neighbourhood-level variables in a second model, but without a contextual variable of the proportion of educated women in a neighbourhood. This was compared with a logistic model. The results are shown in Table 15. The table also presents two other models with the contextual effect of mothers' education (secondary and higher) Appendix R presents the odds ratios for all four models.

Table 15: Estimated coefficients and their associated standard errors of the effect of mothers' education (secondary and higher) on stunting

	Logistic (1)		Multilevel without contextual effect (2)		Multilevel with contextual effect of mothers' secondary education (3)		Multilevel with contextual effect of mothers' higher education (4)	
Fixed effects: Individual-level	**Coeff**	**Std. error**	**Coeff**	**Std. error**	**Coeff**	**Std. error**	**Coeff**	**Std. error**
Child age (Base= below 6)								
6 – 8	0.215***	0.032	0.218***	0.033	0.219***	0.033	0.219***	0.033
9 – 11	0.636***	0.030	0.662***	0.031	0.664***	0.031	0.663***	0.031
12 – 17	1.119***	0.025	1.177***	0.026	1.178***	0.026	1.176***	0.025
18 – 23	1.637***	0.025	1.741***	0.026	1.743***	0.026	1.741***	0.026
24 – 35	1.678***	0.023	1.785***	0.023	1.787***	0.023	1.785***	0.023
36 – 47	1.508***	0.023	1.595***	0.024	1.595***	0.024	1.595***	0.024
48 – 59	1.250***	0.023	1.318***	0.024	1.319***	0.024	1.318***	0.024
Sex of child (Base = Male)								
Female	-0.248***	0.010	-0.266***	0.010	-0.265***	0.010	-0.266***	0.010
Size at birth (Base=very small)								
Small	-0.022	0.024	-0.098***	0.026	-0.091***	0.026	-0.099***	0.026
Average or Larger	-0.381***	0.020	-0.489***	0.022	-0.482***	0.022	-0.490***	0.022
Mother's education (Base=no education)								
Primary	-0.197***	0.011	-0.169***	0.013	-0.121***	0.014	-0.163***	0.013
Secondary	-0.514***	0.015	-0.454***	0.017	-0.298***	0.020	-0.434***	0.017
Higher	-1.146***	0.045	-1.073***	0.048	-0.890***	0.049	-0.872***	0.050
Mother's age	-0.010***	0.001	-0.011***	0.001	-0.010***	0.001	-0.010***	0.001

Table 15, continued

	(1)		(2)		(3)		(4)	
	Coeff	**Std. error**	**Coeff**	**Std. error**	**Coeff**	**Std. error**	**Coeff**	**Std. error**
Improved water source	-0.116***	0.011	-0.093***	0.013	-0.079***	0.013	-0.089***	0.013
Improved sanitation	-0.124***	0.012	-0.160***	0.014	-0.144***	0.014	-0.155***	0.014
Wealth (Base=poorest)								
Poorer	-0.054***	0.014	-0.084***	0.015	-0.083***	0.015	-0.085***	0.015
Middle	-0.126***	0.015	-0.155***	0.017	-0.152***	0.017	-0.155***	0.017
Richer	-0.231***	0.016	-0.272***	0.019	-0.266***	0.019	-0.269***	0.019
Richest	-0.524***	0.021	-0.558***	0.025	-0.551***	0.025	-0.536***	0.025
Age of head of household	-0.002***	0.000	-0.001^{+}	0.000	-0.001^{+}	0.000	-0.001^{+}	0.000
Ever breastfed(Base=Yes)								
No	0.035	0.033	0.060^{+}	0.035	0.059^{+}	0.035	0.060^{+}	0.035
Intercept	-0.793***	0.039	-0.904***	0.043	-0.820***	0.044	-0.882***	0.043
Contextual Effect: Neighbourhood-level variables								
Residence(Base=urban)								
Rural	0.119***	0.014	0.163***	0.018	0.085***	0.018	0.134***	0.018
Altitude	0.0002***	0.000	0.0002***	0.000	0.0002***	0.000	0.0002***	0.000
Proportion of mothers with secondary/higher levels of education					-0.588***	0.034	-1.295***	0.111
Between neighbourhood variance			0.323***	0.009	0.317***	0.009	0.320***	0.009
Intra-class Correlation			0.089***	0.002	0.089***	0.002	0.089***	0.002
Groups	-		15,470		15,470		15,470	
Observations	204,447		204,447		204,447		204,447	
Log-Likelihood	-123079.34		-121162.2		-121011.09		-121090.3	

*p<0.05; **p<0 p<0.05; **p<0.01; ***p<0.001*

Source: Agyen (2020)

From the table, compared to the multilevel models, the standard errors produced by the logistic model clearly underestimate the variability of the coefficient estimates. This is attributed to the fact that, logistic regression models like most traditional regressions treat observations as independent, so in the presence of neighbourhood effect or hierarchical structures, the standard errors of the coefficients would be underestimated (McNeish, 2014). The multilevel model (model 2), however, addresses the issue of dependency between observations in our hierarchical data, therefore, it is considered more appropriate for this study due to the nature of the research question of modelling variability. The multilevel model suggests that in the presence of a neighbourhood (cluster) effect, a child of a given neighbourhood is correlated with all the children of the same neighbourhood.

Model 3 is an expansion of model 2. It adds the contextual effect of the proportion of mothers with secondary education. The addition of the neighbourhood mothers with secondary education substantially reduces the between neighbourhood variance from 0.323 to 0.317, suggesting that the distribution of mothers with secondary education varies across neighbourhoods and contributes to the differences in stunting across neighbourhoods. This is actually anticipated because some neighbourhoods will have higher proportions of educated mothers than others. Model 4 also shows a reduction of between neighbourhood variance from 0.323 to 0.320, suggesting that, the distribution of mothers with higher education contributes to the variations in stunting across neighbourhoods.

The results show that a child is 45 per cent less likely to be stunted when residing in a neighbourhood where all the mothers have secondary education than another residing in a neighbourhood where none of the mothers have a secondary education. It further shows that, a child is 73 per cent less likely to be stunted when living among mothers who have higher education, compared to a child residing in a neighbourhood with none of the mothers obtaining a higher education (see Appendix R).

Evidence suggests that children in rural areas are more stunted than those in urban areas. In an attempt to find whether the contextual effect of mothers' education depends on location (thus, varies with residence), mothers' education is interacted with residence. This interaction effect is illustrated graphically in Figure 18 and presented in Appendix S. Figure 18 shows the relationship between the predicted probability of being stunted and residence for neighbourhood proportions of mothers with at least secondary education of 0.1, 0.25, 0.5 and 0.75.

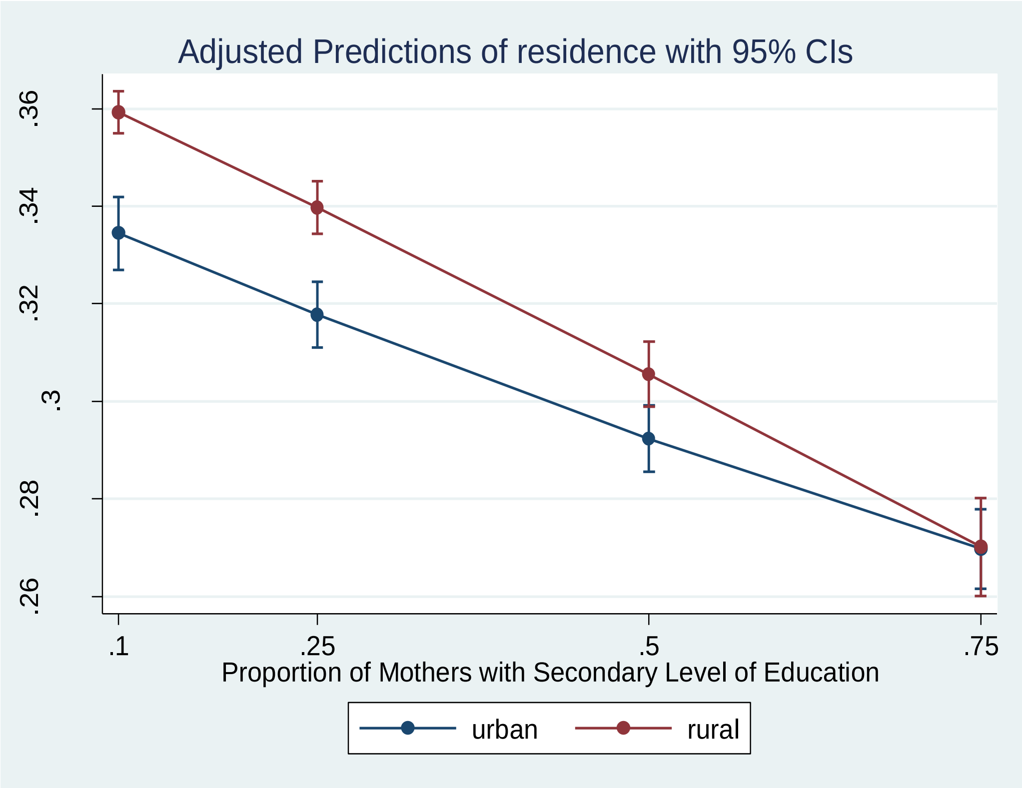


Figure 18: Predicted Probabilities of Being Stunted by Residence and Proportion of Mothers with Secondary Education

Source: Agyen (2020)

The predicted plot shows that the contextual effect of mothers' education in predicted probabilities for mothers' with secondary education is stronger among residents of rural areas. Although a higher proportion of mothers with secondary education in a neighbourhood irrespective of the residence (rural or urban) reduces a child's probability of being stunted, this effect is stronger for children residing in the rural areas than those in the urban. More striking is the fact that, if the proportion of educated women (at least secondary level) is 75 per cent in both rural and urban areas, the probability of being stunted would be the same irrespective of your residence. This finding could be attributed to the fact that social capital networks, which consider connections that enable individuals to relate to each other as argued by Debertin (1996), is quite weak in the urban communities. Residents in rural communities however, are characterised by a strong willingness in participation and involvement in community activities, similar cultural values and live in close proximity to each other. Hence, though social capital networks may exist in both a rural and an urban community, their relevance may vary significantly.

Other Correlates of Stunting

In all models (logistic and multilevel logistic models) the study included individual-level characteristics, maternal and neighbourhood-level factors. These consist of child's age, sex, birth weight, mother's education level, mother's age, water, sanitation, wealth status, age of household head, household size, residence and breastfeeding. These factors show significant association with childhood stunting, consistent with other empirical works on child health (Annim et al., 2012, 2015; Annim & Imai, 2014; Darteh et al., 2014; Frempong & Annim, 2017; Imai et al., 2012).

All the models show a positive relationship between stunting and the age of the child. Children in higher age groups are more likely to be stunted compared to those below 6 months. This finding is corroborated by earlier works by Annim and Imai (2014); and Darteh et al. (2014). In their study Annim and Imai found that height-for-age, weight-for-age and weight-for-height z-scores decrease as a child's age increases. The sign and coefficient of the female variable shows that female children have lesser chance of being stunted compared to male children. Specifically, the odds ratio for model 3 indicate that females are 23 per cent less likely to be stunted than males. This finding is consistent with previous works that found that males have high probability of being malnourished than females (Bork & Diallo, 2017; Wamani et al., 2007). Another significant variable at the level of the child is the size of the child at birth. The results indicate that children who are small, average or larger in size at birth are less likely to be stunted than children who are very small in size.

With regards to maternal factors, the models show that children whose mothers have some level of education (primary, secondary and higher) are less likely to be stunted compared to those whose mothers have no education. Another significant maternal factor is the age of the mother. The study found that an additional age of a mother reduces her child's risk of being stunted by 1 per cent. The reason for this association could be that younger women have an immature demeanor to take proper care of their babies' needs, might breastfeed for a shorter duration, may have less education and might not even have a partner (LeGrand & Mbacké, 1993; Wambach & Cole, 2000). Breastfed children are found to have lesser probability of being stunted than children who have never been breastfed.

To further understand the factors that drive child stunting, the study included household wealth in all the models. The results show that children from poorer, middle, richer and richest households are less likely to be stunted than those in poorest households. Children in households which use improved water and sanitation are less likely to be stunted than their counterparts from households that use unimproved water and sanitation.

Improved but not necessarily good at all places

Improved water is key to health and has been well acknowledged by several studies (Dangour et al., 2013; Fink et al., 2011; Taylor et al., 2015).

Shaheed et al. (2014) however, asserted that improved water sources may not have associated microbial safety as a result of storage or pollution and therefore might not be safe for use. The present study hypothesizes area differences as a pertinent issue in the foregoing effect. This section examines the extent to which effect of improved water on stunting differs across space.

As indicated in the section above on the importance of mothers' education and its variability across locations, there is the need to control for neighbourhood proportion of mothers' education when determining the effect of improved water on stunting across locations. The results are presented in Table 16.

Table 16: Estimates of the effects of improved water on stunting

Stunting	**Random intercept model without interaction term (3)**		**Random intercept model with (water × altitude) (5)**		**Random intercept model with (water × residence)** (6)		**Random slope model (7)**	
Fixed effects: Individual-level	Coeff	Std. error	Coeff	Std. error	Coeff	Std. error	Coeff	Std. error
Child age (Base= Below 6)								
6 – 8	0.219***	0.033	0.218***	0.033	0.219***	0.033	0.219***	0.033
9 - 11	0.664***	0.031	0.664***	0.031	0.664***	0.031	0.667***	0.031
12 – 17	1.178***	0.026	1.177***	0.026	1.178***	0.026	1.186***	0.025
18 – 23	1.743***	0.026	1.743***	0.026	1.743***	0.026	1.756***	0.026
24 – 35	1.787***	0.023	1.787***	0.023	1.787***	0.023	1.800***	0.024
36 – 47	1.595***	0.024	1.595***	0.024	1.595***	0.024	1.606***	0.024
48 – 59	1.319***	0.024	1.318***	0.024	1.319***	0.024	1.328***	0.024
Sex of child (Base = male)								
Female	-0.265***	0.010	-0.265***	0.010	-0.265***	0.010	-0.267***	0.010
Size at birth (Base=very small)								
Small	-0.091***	0.026	-0.092***	0.026	-0.092***	0.026	-0.093***	0.026
Average or larger	-0.482***	0.022	-0.481***	0.022	-0.482***	0.022	-0.486***	0.022
Mother's education (Base=no education)								
Primary	-0.121***	0.014	-0.169***	0.014	-0.122***	0.014	-0.120***	0.014
Secondary	-0.298***	0.020	-0.299***	0.020	-0.298***	0.020	-0.299***	0.020
Higher	-0.890***	0.049	-0.893***	0.049	-0.890***	0.049	-0.890***	0.050
Mother's age	-0.010***	0.001	-0.010***	0.001	-0.010***	0.001	-0.010***	0.001
Improved water source	-0.079***	0.013	-0.113***	0.020	-0.057***	0.014	-0.085***	0.014
Improved sanitation	-0.144***	0.014	-0.144***	0.014	-0.144***	0.014	-0.141***	0.014

Table 16 Continued

	(3)		(5)		(6)		(7)	
	Coeff	Std. error	Coeff	Std. error	Coeff	Std.error	Coeff	Std.error
Wealth (Base=poorest)								
Poorer	-0.083***	0.015	-0.082***	0.015	-0.084***	0.015	-0.085***	0.015
Middle	-0.152***	0.017	-0.152***	0.017	-0.155***	0.017	-0.155***	0.017
Richer	-0.266***	0.019	-0.266***	0.019	-0.266***	0.019	-0.270***	0.019
Richest	-0.551***	0.025	-0.552***	0.025	-0.544***	0.025	-0.558***	0.025
Age of head of household	-0.001^{+}	0.000	-0.001^{+}	0.000	-0.001^{+}	0.000	-0.001^{+}	0.000
Ever breastfed(Base=Yes)								
No	0.059^{+}	0.035	0.060^{+}	0.035	0.059^{+}	0.035	0.062^{+}	0.035
Intercept	-0.820***	0.044	-0.797***	0.045	-0.734***	0.048	-0.823***	0.044
Contextual effect: Neighbourhood-level variables								
Residence(Base=urban)								
Rural	0.085***	0.018	0.084***	0.018	-0.012	0.030	0.081***	0.019
Altitude	0.0002***	0.000	0.0002***	0.000	0.0002***	0.000	0.0002***	0.000
Proportion of mothers with Sec/higher levels of education	-0.588***	0.034	-0.587***	0.034	-0.584***	0.034	-0.594***	0.034
Interaction term (water × altitude)			0.00005*	0.000				
Interaction term (water × residence)					-0.129***	0.032		
Between neighbourhood variance	**0.317*** **	**0.009**	**0.316*** **	**0.009**	**0.316*** **	**0.009**	**0.320*** **	**0.009**
Var(water)							0.307	0.026
Cov(water,cons)							-0.158	0.017
Intra-class Correlation	0.089***	0.002	0.089***	0.002	0.087***	0.002	0.100***	0.004
Groups	15,470		15,470		15,470		15,470	
Observations	204,447		204,447		204,447		204,447	
Log-Likelihood	-121011.09		-121086.93		-121003.16		-120908.8	

*p<0.05; **p<0.01; ***p<0.001*

Models 5 and 6 presents cross-level interaction terms between altitude and improved water, and residence and improved water. For comparison the table presents estimates from the model, 3 without the interaction term. The estimates for the fixed models (3, 5 and 6) in Table 16 are quite similar for all models except the slopes of the variables in the interaction terms. The coefficient for the interaction of altitude and improved water is 0.0005 which is significant at 1 per cent p-value, though very small. On the other hand, the interaction term that the effect of improved water on stunting depends on residence is -0.129 and also significant at 1 per cent p-value. This shows that the slopes of the regression lines between improved water and stunting are different for rural areas and urban areas. The negative relationship implies that with urban areas, the effect of improved water on stunting is greater. A clearer diagrammatic representation of this interaction is in Figure 19. The results indicate that if all the factors driving stunting remain the same but all the children in our sample resided in urban areas and had no improved water, about 36.76 per cent would be stunted. This is almost the same, even slightly higher than when the children resided in rural areas and had no improved water (36.52). However, if all the other factors again remain the same but all the children in our sample resided in urban areas and had improved water, about 33.15 per cent would be stunted. On the other hand, the probability of being stunted if the child resided in a rural area and had improved water is 35.41 per cent holding all other variables constant (at their means). It is observed that the difference in predictive margins for urban areas $(36.76 - 33.15 = 3.61)$ is greater than for rural areas $(36.52 - 35.41 = 1.11)$. This finding clearly indicates that improved water may be more effective in urban areas compared to rural areas. This raises concern and questions the quality of improved water in rural areas.

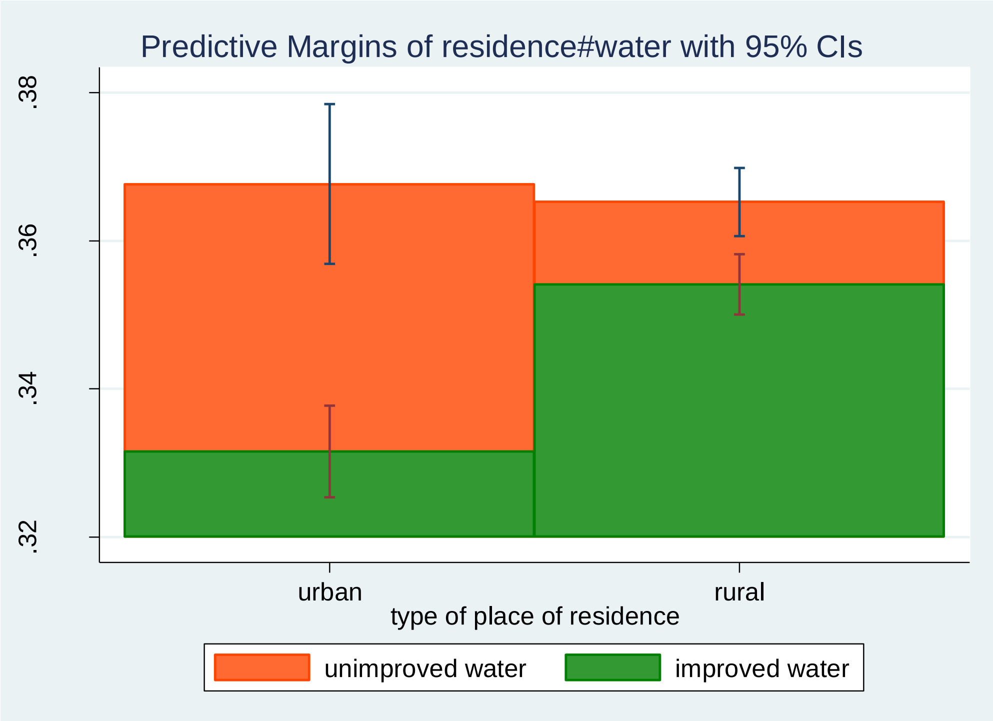


Figure 19: Predictive Margins of the effect of improved water on stunting depending on residence

Source: Agyen (2020)

The study further tests for the interaction effect between residence and piped water only. The results are presented in Appendix T and Appendix U. The results show that holding all other factors driving stunting at their means but all the children in our sample resided in urban areas and had no piped water, about 35.46 per cent would be stunted. This is slightly lower than when the children resided in rural areas and had no piped water (36.07%). However, if all the other factors again remain the same but all the children in our sample resided in urban areas and had piped water, about 32.32 per cent would be stunted. On the other hand, the probability of being stunted if the child resided in a rural area and had piped water is 34.89 per cent holding all other variables constant (at their means). It is observed that the difference in predictive margins for urban areas $(35.46 - 32.32 = 3.14)$ is greater than for rural areas $(36.07 - 34.89 = 1.18)$. This suggests that in rural areas piped water reduces a child's probability of being stunted by only 1 per cent and 3 per cent for another child in the urban area.

The models fitted in model 5 and 6 allow the probability of being stunted to depend on neighbourhoods by allowing the intercepts to vary randomly across neighbourhoods in a random intercept model. The study in Model 7 allows for both the intercept and the slope of improved water to vary randomly across neighbourhoods. The results are presented in the last two columns in Table 16.

In model 7 two new parameters (slope variance and intercept-slope covariance) are observed as a result of the extension from random intercepts in the previous models to a random slope model. The effect of improved water on the odds of being stunted in a given neighbourhood j, for example, is estimated as $-0.085 + \widehat{u_{6j}}$. The slope variance of 0.307 is the between-state variance in the effect of improved water. Since improved water has been centred about its sample mean, the intercept variance of 0.32 is the between-neighbourhood variance in the log-odds of stunting at the sample proportion of the improved water source.

With regards to the intercept and slope residuals for neighbourhoods, the negative intercept-slope covariance estimate (-0.158) shows that neighbourhoods with above average prevalence of stunting (intercept residual > 0) also have below-average effect of improved water (slope residual < 0). In other words, there is less impact of improved water on stunting in neighbourhoods with high prevalence. The plot of the neighbourhood slopes versus the neighbourhood intercepts for improved water sources is presented in Appendix V. It is clear from the graph that the relationship between improved water and stunting differs across neighbourhoods.

The likelihood ratio test of no neighbourhood variation in the effect of improved water is examined. Using the log-likelihood values of the model with and without the random slope for improved water, the likelihood ratio test statistic (204.48) is twice the difference of these values. The 5 per cent point of a chi-squared distribution on 2 degrees of freedom is 5.991. The null hypothesis of no neighbourhood variation of improved water is rejected. The study therefore concludes that the random effect for improved water is statistically significant.

Chapter Summary

This empirical chapter has presented the results and discussion of the effect of neighbourhood differences on child health. The results show hot-spots or clusters of high prevalence of stunting in some parts of Sub-Saharan Africa (predominantly around Congo and Madagascar) and low-spots in other regions.

To investigate the differences in the neighbourhood effects of the correlates of stunting. The study examined the proportion of mothers' education in each neighbourhood on stunting. The analysis found that the effect of neighbourhood mothers' education on stunting reduces the differences in the prevalence of stunting between neighbourhoods and indicated a stronger effect in rural area than urban. It shows that the rural-urban gap regarding stunting in Sub-Saharan Africa can be bridged if each community has a proportion of 75 per cent of mother's with secondary education.

Results from the hypothesis that the effect of improved water differs across neighbourhoods found that location affects the relationship between improved water sources and child health. The predictive margins of water dependent on residence indicate that the effect of improved water on stunting is less in rural areas and high in urban. The random slope model found significant variations in the effect of improved water across neighbourhoods. The results suggest that the impact of improved water on stunting is less in neighbourhoods with high prevalence of stunting and high in those with low prevalence.

The next chapter presents a summary of the findings from the three thematic areas of enquiry. It presents results on the assessment of spatial dependence of stunting in children, the effects of neighbouring mothers' education on child health, and the differences in the neighbourhood effects of the correlates of stunting. Conclusions are drawn from key findings which inform the recommendations suggested by the study.

CHAPTER EIGHT

SUMMARY, CONCLUSION AND POLICY RECOMMENDATION

Introduction

Although global trends of stunting among other child health indicators show significant declines, one overarching challenge that has attracted attention is disparities. Policy makers, researchers and public health practitioners have sought to understand the context and reduce or possibly eliminate health disparities among populations to achieve health equity. Design of an effective implementation strategy for the reduction or eradication of spatial health disparities is hindered by difficulties in measuring and identifying the extent of health disparities due to limited spatial information and limited methods. This study, therefore, employed appropriate spatial econometric tools to examine the spatial dependence that exists in health at the district (administrative area) and cluster or neighbourhood level. It looked at some area and social factors that contribute to these health disparities. The study also considered alternative ways of measuring spatial dependence in the absence of spatial data at the individual level, and finally looked at child stunting and its determinants in Sub-Saharan Africa, with emphasis on the differences in the neighbourhood effects of its correlates.

This chapter first presents a summary of the whole thesis, with specific attention to the empirical findings from all three empirical chapters. This is followed by the conclusions drawn from the study. It entails a review of significant points in this thesis and a clarification of their relevance. The chapter then presents recommended policies based on the findings and suggests areas for future research.

Summary

The association between health and place has been well documented, leading to a spring up of studies that help address health problems and its related variations. In Ghana, the role of place on child health outcomes is evident in national reports and statistics from national surveys (GDHS and GLSS) and through regional and district variations. For this reason, it is imperative to use a suitable econometric design to examine area characteristics as a determinant of child health, beyond and above individual-level risk factors.

To this end, the first empirical chapter has been undertaken to help mitigate stunting in Ghana by examining the variations thus: identifying areas, including districts with higher prevalence and accounting for area characteristics that induce these variations. The main variable of interest – neighbourhood effect – was captured using the average of the proportion of stunted children within the four nearest clusters of households (with respect to point/cluster analysis) and the average of the proportion of stunted children in districts that share common boundaries (with respect to district-level analysis). Neighbourhood mothers' education was also captured using the average of the highest level of education of mothers within the four nearest clusters of households (with respect to point analysis) and the average of the highest level of education of mothers in districts that share common boundaries (with respect to district level analysis). In testing the relationship between neighbourhoods or areas of residence and stunting, the study was premised on the hypothesis that the proportion of stunting in a cluster of households or districts is positively influenced by neighbouring clusters of households' or districts' characteristics.

Several analyses were employed to test the hypothesis. First, a multivariate logistic regression at the individual level was carried out. This was followed by a multilevel analysis to compare coefficients with the logistic model to ascertain similarities or clustering at the group level. Owing to the nature of the dataset, ESDA on stunting proportions were explored to test for spatial autocorrelation, and it was found to be present and significant with LISA and Global Moran's Index. The study used two different spatial regression techniques (SAR and SEM) to ascertain the effect of neighbourhoods on stunting. Then, the study used LISA and the spatial cross-regressive model to examine the effect of neighbourhood mothers' education on stunting.

The study found significant clustering of stunting in children below 5 years across districts in Ghana where 17 districts with high rates of stunting are clustered in the north-eastern part of Ghana. For stunting rates, the effect of adjacent neighbourhood districts is 19 per cent as high as it is in the focal district, indicating a spillover effect. It was also observed that mothers with less education are clustered in the northern part of Ghana and those with high education, are clustered in some parts of the south. The study found that in addition to a child's own-mothers' years of education, neighbouring mothers' years of education helps reduce child stunting. These findings suggest that neighbourhood effects are important in determining child stunting in Ghana.

The second empirical chapter used structural equation modelling to estimate a more complex system of relationships and mediated effects on child health. Premised on the theory of social capital, externalities, proximity and intersectionality, three main hypotheses were tested: (1) type of residence, neighbours' wealth, neighbouring mothers' education, distance to a health centre, sanitation and water sources are indicators of neighbourhood or spatial effects; (2) socioeconomically advantaged neighbourhoods improve child health; and (3) the relationship between neighbouring mothers' education and child health is moderated by the child's own mother's education.

The study used the latent variable approach to estimate indicators for spatial dependence or neighbourhood effect. In this chapter, the study adopted the definition of neighbourhood in spatial analysis to a measurement model in structural equation modelling. Neighbourhood mothers' education for each observation (each child) was measured as an average of the years of education of all mothers in the same cluster, without the observation's own mother's years of education. The same strategy was used for neighbourhood wealth. The model was a good fit to the data used and confirmed type of residence, neighbours' wealth, neighbouring mothers' education, distance to health centre, sanitation and water sources as good indicators of neighbourhood or spatial effects.

The study found that children residing in advantaged neighbourhoods (wealthy neighbours, mothers' with more years of education, no problems accessing – or in close proximity to – health centres, improved water source, improved sanitation, and urban areas) have better health statuses compared to their counterparts living in disadvantaged neighbourhoods. The study found that mother's education improves child health and mediates the relationship between neighbouring mother's education and child nutritional status.

The third empirical study tested three main hypotheses: (1) neighbourhoods where mothers have secondary and higher levels of education, significantly improve a child's health over and above the child's own mother's education (2) the effect of the proportion of mothers' education on stunting varies across neighbourhoods, and (3) the effect of improved water on stunting varies across neighbourhoods. The chapter used DHS datasets from 30 Sub-Saharan African countries with a sample of 245,426 children (72,544 from urban areas and 172,882 from rural areas) under 5. This sample was used in a spatial analysis, while 233,314 children (without children from Madagascar) were used to estimate multilevel random intercept models and random slope models.

The main finding suggests that the proportion of mothers' respective levels of education in a community drives neighbourhood differences between communities. This indicates that the distribution of neighbourhood mothers' education varies across neighbourhoods and helps explain why some communities have a higher prevalence of stunted children. A prediction of the probability of being stunted on residence for proportions of neighbourhood mothers' education suggests that the probability that a child residing in a rural area would be stunted would be the same for a child residing in an urban area if each area had 75 per cent of mothers with at least secondary education. This result shows a greater effect of neighbourhood mothers' education in rural areas than in the urban, which can be explained by the varying relevance of social capital networks between rural and urban communities. The urban communities, unlike rural, are often perceived as anti-social to the extent that residents may even have no knowledge about those living in close proximity, whiles the rural areas are characterised by similar cultural values, strong willingness in participation and involvement in community activities.

For the varying neighbourhood effect of improved water on stunting, the study found that location affects the relationship between improved water sources and child health. It indicates that the effect of improved water on stunting is less (1 per cent) in rural areas and high (4 per cent) in urban areas. This finding raises concerns about the quality of improved water in rural areas compared to urban areas. Using piped water for a more specific analysis of improved water suggests that in rural areas piped water reduces a child's probability of being stunted by only 1 per cent, which is lower than 3 per cent for another child in the urban area. The results also show that the impact of improved water on stunting is less in neighbourhoods with high prevalence of stunting and high in low prevalence areas.

Conclusion

The study has argued that neighbourhoods or spatial effects are important in explaining variations in child health across different sub-groups of the population. Evidence from this thesis affirms all research hypotheses.

Concerning the first empirical chapter, the identification of high-stunted clusters is important for targeted policy design to fight child malnutrition in Ghana. In addition to informing local place-based initiatives, the finding supports local planning, supervision and monitoring efforts on child health outcomes and child health equity. It shows and identifies most districts – especially in the north eastern part of Ghana – with higher rates of stunting that share boundaries with districts where there are equally high rates of stunting. The finding on the effect of neighbouring districts' characteristics on stunting rates deepens the understanding of the influence of neighbourhoods on health and the emergence of child health inequalities. Suggested evidence corroborates the theory of social capital, externalities and the concept of proximity that, neighbourhoods could place contextual effects on individual health and well-being through diffusion or dissemination of health-related information and norms, the accessibility of local services and amenities, and mutual support systems. The effect of neighbouring mothers' education on the rate of stunting in districts and clusters suggests that women's education, through the concept of social capital and positive externalities, may have a greater effect than what we had known it to be.

Despite the extant literature on the factors that drive child health, there is evidence of the interrelationships between these factors. The second empirical chapter tested the effect of socioeconomically advantaged neighbourhoods on child health and the pathway through which neighbouring mothers' education affects child health. The evidence from this chapter provides a better understanding of the implicit complexities of the paths that drives child health outcomes. The study suggests that child-level characteristics, maternal, household and geographic characteristics directly and indirectly affect child health through the intersectional associations of these factors. Evidence of the effect of socioeconomically advantaged neighbourhoods, measured by neighbourhood factors suggests that children who live in socioeconomically disadvantaged neighbourhoods have poor health, and vice versa. This calls for a more critical review and clearer perspectives on the composition of neighbourhoods targeted towards local or area-specific initiatives.

The third empirical chapter concludes on the assertion that neighbourhood effects on the correlates of stunting are not homogenous. Two conclusions are drawn from this. First is that the difference in the risk on being stunted between a child in a rural area and another in the urban area is smaller, with more secondary level educated mothers in each locality. This highlights the importance of the education of mothers and touts it as an effective variable to help reduce stunting inequalities in children under 5. The second, however, postulates that the effect of improved water on stunting is less in rural areas and areas with high prevalence of stunting compared to urban areas and those with low prevalence of stunting. This raises concern about differences in quality of improved water across areas.

In general, the thesis has shown the importance of location and its implication on child health. Undoubtedly this concept is crucial for concepts, research and policy planning on child health.

Recommendations

Based on the results from this study, a one-size-fits-all intervention will not be the best way to improve child health in Ghana and Sub-Saharan Africa. The study, therefore, proposes the following policy recommendations.

1. Initiatives to address stunting should be broadened to cover neighbouring districts with the likelihood of contributing to poor child health outcomes in adjoining settlements.
2. **Programs:** The study recommends district- or area-specific interventions such as area-specific campaigns and community organisations as more effective in mitigating stunting. With the help of the Ministry of Gender and Child Protection, community

and district durbars or meetings which are organised by the Department of Social Welfare can engage some educated mothers from the same communities or districts to share their knowledge on best practices for childcare. As suggested by The Productivity Commission (2003) this will provide a basis for trust and social inclusion and ultimately strengthen social capital in these communities or districts.

3. **Methodology:** More spatial data are needed on communities, institutions and resources to help determine spatial and contextual effects for a more targeted health-related policy.

   Contextual analysis is important in estimating the factors that drive child health and, therefore, this study recommends more robust methods of estimation (such as, spatial regressions, multilevel or hierarchical models and structural equation models) over the traditional standard regression methods.

4. **Policy**: From a policy perspective, the study supports interventions that target women's education, especially in areas with higher rates of poor child health outcomes (such as the northern part of Ghana). For example, the Girl's Model School initiative by Oxfam in some communities in the northern region of Ghana can be supported and expanded to the secondary education level. The initiative which is aimed at getting girls – especially teenage mothers – into school, is only at the junior high level and in few districts.

   The study also recommends development of industries or factories including those that require some level of education in areas where stunting rates are high to help women with secondary levels of education and higher find jobs in these areas after their education and avoid migration to the southern part of the country.

5. **Policy**: For policy makers across Sub-Saharan Africa, the study recommends centralized treatment centres to supply water to both rural and urban areas to promote equitable access. This calls for improvement in service delivery through investment in water production and expanded network coverage in the water sector. This will help reduce poor quality of water in some areas and shortages in water supply in certain areas. The study again cautions for the need for a careful interpretation of the definition of 'improved water' in research since the current WHO definition does not absorb the issues of reliability, frequency of access and quality which are key area-specific issues to the effect of water on child health. The study, therefore, recommends a definition that absorbs metrics for safety, reliability, frequency and quality.

Suggestions for Future Research

In addition to advancing knowledge on the understanding of under-5 child health inequalities and the role of location, this study arouses interesting issues meriting further research. The following provides an outline for future studies:

1. Estimate the effect of the duration of exposure to certain neighbourhood conditions on child health, using longitudinal studies.

2. An analysis of the cumulative effects of neighbourhood characteristics at different times over the life course of a child, using longitudinal studies.
3. Targeted research on the health impacts of specific improved water sources such as piped and protected wells across space.
4. Estimate the effect of improved water on child health using a holistic measure of availability, accessibility and safety.
5. An analysis of neighbourhood effects on child health using a qualitative or mixed method approach.

This thesis has demonstrated the role of location in understanding the social determinants of under 5 child health and health inequalities. The results highlighted the importance of women's education and how this could be used as a tool to bridge child health inequalities. Based on the research findings, the study recommended area-specific initiatives over one-size-fits-all policies and made suggestions for future research.

BIBLIOGRAPHY

Abarca-Gómez, L., Abdeen, Z. A., Hamid, Z. A., Abu-Rmeileh, N. M., Acosta-Cazares, B., Acuin, C., Adams, R. J., Aekplakorn, W., Afsana, K., Aguilar-Salinas, C. A., Agyemang, C., Ahmadvand, A., Ahrens, W., Ajlouni, K., Akhtaeva, N., Al-Hazzaa, H. M., Al-Othman, A. R., Al-Raddadi, R., Al Buhairan, F., … Ezzati, M. (2017). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *The Lancet*, *390*(10113), 2627–2642. https://doi.org/10.1016/S0140-6736(17)32129-3

Abdul-Sattar, A. B., & Abou El Magd, S. (2017). Association of perceived neighborhood characteristics, socioeconomic status and rural residency with health outcomes in E gyptian patients with systemic lupus erythematosus: One center study. *International Journal of Rheumatic Diseases*, *20*(12), 2045–2052.

Aber, J. L., Bennett, N. G., Conley, D. C., & Li, J. (1997). The Effects of Poverty on Child Health and Development. *Annual Review of Public Health*, *18*(1), 463–483. https://doi.org/10.1146/ annurev.publhealth.18.1.463

Addai, I. (2000). Determinants of use of maternal-child health services in rural Ghana. *Journal of Biosocial Science*, *32*(1), 1–15.

Adekanmbi, V. (2015). *Unravelling the Effects of Neighbourhood Contextual Influences on Childhood Mortality and Morbidity in Nigeria* [PhD Thesis]. University of Warwick.

Adekanmbi, V., Uthman, O., & O Mudasiru, O. (2013). Exploring variations in childhood stunting in Nigeria using league table, control chart and spatial analysis. *BMC Public Health*, *13*, 361. https://doi.org/10.1186/1471-2458-13-361

Adewara, S. O., & Visser, M. (2011). Use of Anthropometric Measures to Analyze How Sources of Water and Sanitation Affect Chidren's Health in Nigeria. In *Discussion Papers* (dp-11-02-efd; Discussion Papers). Resources For the Future. https://ideas.repec.org/p/rff/dpaper/dp-11-02-efd.html

Agüero, J., & Bharadwaj, P. (2014). Do the More Educated Know More about Health? Evidence from Schooling and HIV Knowledge in Zimbabwe. *Economic Development and Cultural Change*, *62*(3), 489–517.

Aheto, J. M. K., Keegan, T. J., Taylor, B., & Diggle, P. J. (2015a). Childhood Malnutrition and Its Determinants among Under-Five Children in Ghana. *Paediatric and Perinatal Epidemiology*, *29*(6), 552–561. https://doi.org/10.1111/ppe.12222

Aheto, J. M. K., Keegan, T. J., Taylor, B. M., & Diggle, P. J. (2015b). Childhood Malnutrition and Its Determinants among Under-Five Children in Ghana. *Paediatric and Perinatal Epidemiology*, *29*(6), 552–561. https://doi.org/10.1111/ppe.12222

Aheto, J. M. K., Taylor, B. M., Keegan, T. J., & Diggle, P. J. (2017). Modelling and forecasting spatio-temporal variation in the risk of chronic malnutrition among under-five children in Ghana. *Spatial and Spatio-Temporal Epidemiology*, *21*, 37–46. https://doi.org/10.1016/j.sste.2017.02.003

Ahmed, T., Hossain, M., & Sanin, K. I. (2012). Global Burden of Maternal and Child Undernutrition and Micronutrient Deficiencies. *Annals of Nutrition and Metabolism*, *61*(Suppl. 1), 8–17. https://doi.org/10 .1159/ 000345165

Alam, N. (2000). Teenage motherhood and infant mortality in Bangladesh: Maternal age-dependent effect of parity one. *Journal of Biosocial Science*, *32*(2), 229–236. https://doi.org/10.1017/s0021932000002297

Alemayehu Azeze, A., & Huang, W. (2014). Maternal Education, Linkages and Child Nutrition in the Long and Short-run: Evidence from the Ethiopia Demographic and Health Surveys. *International Journal of African Development*, *1*(2). https://scholarworks.wmich.edu/ijad/vol1/ iss2/3

Álvarez, E. C., & Romaní, J. R. (2017). Measuring social capital: Further insights. *Gaceta Sanitaria*, *31*(1), 57–61. https://doi.org/10.1016/j. gaceta.2016.09.002

Ambel, A. A., Andrews, C., Bakilana, A. M., Foster, E. M., Khan, Q., & Wang, H. (2017). Examining changes in maternal and child health inequalities in Ethiopia. *International Journal for Equity in Health, 16*(1), 152. https://doi.org/10.1186/s12939-017-0648-1

Anderson, L. R., Mellor, J. M., & Milyo, J. (2004). Social Capital and Contributions in a Public-Goods Experiment. *American Economic Review*, *94*(2), 373–376. https://doi.org/10.1257/0002828041302082

Andrade, I. G., Queiroz, J. W., Cabral, A. P., Lieberman, J. A., & Jeronimo, S. M. B. (2009). Improved sanitation and income are associated with decreased rates of hospitalization for diarrhoea in Brazilian infants.

Transactions of The Royal Society of Tropical Medicine and Hygiene, *103*(5), 506–511.

Andriano, L., & Monden, C. W. S. (2019). The Causal Effect of Maternal Education on Child Mortality: Evidence From a Quasi-Experiment in Malawi and Uganda. *Demography*, *56*(5), 1765–1790. https://doi.org/10.1007/s13524-019-00812-3

Annim, S. K., Awusabo-Asare, K., & Amo-Adjei, J. (2015). HOUSEHOLD NUCLEATION, DEPENDENCY AND CHILD HEALTH OUTCOMES IN GHANA. *Journal of Biosocial Science*, *47*(5), 565–592. https://doi.org/10.1017/S0021932014000340

Annim, S. K., & Imai, K. (2014). Nutritional Status of Children, Food Consumption Diversity and Ethnicity in Lao PDR. *REIB Working Papers, DP2014-17*.

Annim, S. K., Mariwah, S., & Sebu, J. (2012). Spatial inequality and household poverty in Ghana. *Economic Systems*, *36*(4), 487–505. https://doi.org/10.1016/j.ecosys.2012.05.002

Anselin, L. (1988). *Spatial econometrics: Methods and models*. Kluwer Academic Publishers.

Anselin, L. (1990). Some robust approaches to testing and estimation in spatial econometrics. *Regional Science and Urban Economics*, *20*(2), 141–163. https://doi.org/10.1016/0166-0462(90)90001-J

Anselin, L. (1998). *Exploratory spatial data analysis in geocomputational environment*.

Anselin, L. (2003). Spatial Econometrics. In B. H. Baltagi (Ed.), *A Companion to Theoretical Econometrics* (pp. 310–330). Blackwell Publishing Ltd. https://doi.org/10.1002/9780470996249.ch15

Anselin, L. (2017). *A Local Indicator of Multivariate Spatial Association*. https://doi.org/10.13140/RG.2.2.18101.58084

Arcaya, M., Brewster, M., Zigler, C. M., & Subramanian, S. V. (2012). Area variations in health: A spatial multilevel modeling approach. *Health & Place*, *18*(4), 824–831.

Arcaya, M. C., Arcaya, A. L., & Subramanian, S. V. (2015a). Inequalities in health: Definitions, concepts, and theories. *Global Health Action*, *8*, 27106. https://doi.org/10.3402/gha.v8.27106

Arcaya, M. C., Arcaya, A. L., & Subramanian, S. V. (2015b). Inequalities in health: Definitions, concepts, and theories. *Global Health Action*, *8*. https://doi.org/10.3402/gha.v8.27106

Audsley, A., Wallace, R. M. M., & Price, M. F. (2016). Mountain Child: Systematic Literature Review. *Maternal and Child Health Journal*, *20*(12), 2415–2423. https://doi.org/10.1007/s10995-016-2051-8

Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. *Journal of the Academy of Marketing Science*, *16*(1), 74–94. https://doi.org/10.1007/BF02723327

Bain, R., Wright, J., Yang, H., Gundry, S., Pedley, S., & Bartram, J. (2012). Improved but not necessarily safe: Water access and the Millennium Development Goals. In Q. Grafton, P. Wyrwoll, C. White, & D. Allendes (Eds.), *Global Water: Issues and Insights* (1st ed.). ANU Press. https://doi.org/10.22459/GW.05.2014.16

Ballantine, K., Schneider, R., Groffman, P., & Lehmann, J. (2012). Soil Properties and Vegetative Development in Four Restored Freshwater Depressional Wetlands. *Soil Science Society of America Journal*, *76*(4), 1482–1495. https://doi.org/10.2136/sssaj2011.0362

Barcikowski, R. S. (1981). Statistical Power with Group Mean as the Unit of Analysis,Statistical Power with Group Mean as the Unit of Analysis. *Journal of Educational Statistics*, *6*(3), 267–285. https://doi.org/10.3102/10769 986006003267

Bartley, M. (2017). *Health inequality: An introduction to concepts, theories and methods*. John Wiley & Sons.

Basta, L. A., Richmond, T. S., & Wiebe, D. J. (2010). Neighborhoods, daily activities, and measuring health risks experienced in urban environments. *Social Science & Medicine (1982)*, *71*(11), 1943–1950. https://doi.org/10.1016/j.socscimed.2010.09.008

Basu, A. M., & Stephenson, R. (2005). Low levels of maternal education and the proximate determinants of childhood mortality: A little learning is not a dangerous thing. *Social Science & Medicine*, *60*(9), 2011–2023. https://doi.org/10.1016/j.socscimed.2004.08.057

Bauer, G. R. (2014). Incorporating intersectionality theory into population health research methodology: Challenges and the potential to advance health equity. *Social Science & Medicine (1982)*, *110*, 10–17. https://doi.org/10.1016/j.socscimed.2014.03.022

Behrman, J. A. (2015). Does Schooling Affect Women's Desired Fertility? Evidence From Malawi, Uganda, and Ethiopia. *Demography*, *52*(3), 787–809. https://doi.org/10.1007/s13524-015-0392-3

Benefo, K., & Schultz, T. P. (1996). Fertility and child mortality in Cote d'Ivoire and Ghana. *The World Bank Economic Review*, *10*(1), 123–158. https://doi.org/10.1093/wber/10.1.123

Bernard, P., Charafeddine, R., Frohlich, K. L., Daniel, M., Kestens, Y., & Potvin, L. (2007a). Health inequalities and place: A theoretical conception of neighbourhood. *Social Science & Medicine*, *65*(9), 1839–1852.

Bernard, P., Charafeddine, R., Frohlich, K. L., Daniel, M., Kestens, Y., & Potvin, L. (2007b). Health inequalities and place: A theoretical conception of neighbourhood. *Social Science & Medicine (1982)*, *65*(9), 1839–1852. https://doi.org/10.1016/j.socscimed.2007.05.037

Bhutta, Z. (2004). Beyond Bellagio: Addressing the challenge of sustainable child health in developing countries. *Archives of Disease in Childhood*, *89*(5), 483–487. https://doi.org/10.1136/adc.2003.045732

Bicego, G. T., & Boerma, J. T. (1990). Maternal education, use of health services, and child survival: An analysis of data from the Bolivia DHS Survey. In *DHS Working Papers No. 1: Vol. DHS Working Papers No. 1*. Macro Systems Inc. http://dhsprogram.com/pubs/pdf/WP1/WP1.pdf

Bissonnette, L., Wilson, K., Bell, S., & Shah, T. I. (2012). Neighbourhoods and potential access to health care: The role of spatial and aspatial factors. *Health & Place*, *18*(4), 841–853. https://doi.org/10.1016/j.healthplace.2012.03.007

Black, J., & Veenstra, G. (2011). A cross-cultural quantitative approach to intersectionality and health: Using interactions between gender, race, class and neighbourhood to predict self-rated health in Toronto and

New York City. *Health Inequities in Canada: Intersectional Frameworks and Practices*, *71*, 91.

Black, R. E., Allen, L. H., Bhutta, Z. A., Caulfield, L. E., Onis, M. de, Ezzati, M., Mathers, C., & Rivera, J. (2008). Maternal and child undernutrition: Global and regional exposures and health consequences. *The Lancet*, *371*(9608), 243–260. https://doi.org/10.1016/S0140-6736(07)61690-0

Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., Onis, M. de, Ezzati, M., Grantham-McGregor, S., Katz, J., Martorell, R., & Uauy, R. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet*, *382*(9890), 427–451. https://doi.org/10.1016/S0140-6736(13)60937-X

Borja, J. B., & Adair, L. S. (2003). Assessing the net effect of young maternal age on birthweight. *American Journal of Human Biology: The Official Journal of the Human Biology Council*, *15*(6), 733–740. https://doi.org/10.1002/ajhb.10220

Bork, K. A., & Diallo, A. (2017). Boys Are More Stunted than Girls from Early Infancy to 3 Years of Age in Rural Senegal. *The Journal of Nutrition*, *147*(5), 940–947. https://doi.org/10.3945/jn.116.243246

Bouvier, P., Papart, J. P., Wanner, P., Picquet, M., & Rougemont, A. (1995). Malnutrition of children in Sikasso (Mali): Prevalence and socio-economic determinants. *Sozial- Und Praventivmedizin*, *40*(1), 27–34. https://doi.org/10.1007/BF01615659

Bowleg, L. (2012). The Problem With the Phrase Women and Minorities: Intersectionality—an Important Theoretical Framework for Public Health. *American Journal of Public Health*, *102*(7), 1267–1273. https://doi.org/10.2105/AJPH.2012.300750

Bramlett, M. D., & Blumberg, S. J. (2007). Family structure and children's physical and mental health. *Health Affairs*, *26*(2), 549–558.

Brown, K. H., & Solomons, N. W. (1991). Nutritional problems of developing countries. *Infectious Disease Clinics of North America*, *5*(2), 297–317.

Burstein, R., Henry, N. J., Collison, M. L., Marczak, L. B., Sligar, A., Watson, S., Marquez, N., Abbasalizad-Farhangi, M., Abbasi, M., Abd-Allah, F., Abdoli, A., Abdollahi, M., Abdollahpour, I., Abdulkader, R. S., Abrigo, M. R. M., Acharya, D., Adebayo, O. M., Adekanmbi, V., Adham, D., … Hay, S. I. (2019). Mapping 123 million neonatal, infant and child deaths between 2000 and 2017. *Nature*, *574*(7778), 353–358. https://doi.org/10.1038/s41586-019-1545-0

Byrnes, H. F., Miller, B. A., Chen, M.-J., & Grube, J. W. (2011). The Roles of Mothers' Neighborhood Perceptions and Specific Monitoring Strategies in Youths' Problem Behavior. *Journal of Youth and Adolescence*, *40*(3), 347–360. https://doi.org/10.1007/s10964-010-9538-1

Caldwell, J., & McDonald, P. (1982). Influence of maternal education on infant and child mortality: Levels and causes. *Health Policy and Education*, *2*(3–4), 251–267. https://doi.org/10.1016/0165-2281(82)90012-1

Casale, D., Espi, G., & Norris, S. A. (2018). Estimating the pathways through which maternal education affects stunting: Evidence from an urban cohort in South Africa. *Public Health Nutrition*, *21*(10), 1810–1818. https://doi.org/10.1017/S1368980018000125

Chaix, B., Kestens, Y., Perchoux, C., Karusisi, N., Merlo, J., & Labadi, K. (2012). An interactive mapping tool to assess individual mobility patterns in neighborhood studies. *American Journal of Preventive Medicine*, *43*(4), 440–450. https://doi.org/10.1016/j.amepre.2012.06.026

Chen, Y., & Li, H. (2009). Mother's education and child health: Is there a nurturing effect? *Journal of Health Economics*, *28*(2), 413–426. https://doi.org/10.1016/j.jhealeco.2008.10.005

Choby, A. A., & Clark, A. M. (2014). Improving health: Structure and agency in health interventions. *Nursing Philosophy: An International Journal for Healthcare Professionals*, *15*(2), 89–101. https://doi.org/10.1111/nup.12018

Christian, P., Lee, S. E., Donahue Angel, M., Adair, L. S., Arifeen, S. E., Ashorn, P., Barros, F. C., Fall, C. H., Fawzi, W. W., Hao, W., Hu, G., Humphrey, J. H., Huybregts, L., Joglekar, C. V., Kariuki, S. K., Kolsteren, P., Krishnaveni, G. V., Liu, E., Martorell, R., … Black, R. E. (2013). Risk of childhood undernutrition related to small-for-gestational age and preterm birth in low- and middle-income countries. *International Journal of Epidemiology*, *42*(5), 1340–1355. https://doi.org/10.1093/ije/dyt109

Chum, A., O'Campo, P., Lachaud, J., Fink, N., Kirst, M., & Nisenbaum, R. (2019). Evaluating same-source bias in the association between neighbourhood characteristics and depression in a community sample from Toronto, Canada. *Social Psychiatry and Psychiatric Epidemiology*, *54*(10), 1177–1187. https://doi.org/10.1007/s00127-019-01718-6

Clark, A. M. (1998). The qualitative-quantitative debate: Moving from positivism and confrontation to post-positivism and reconciliation. *Journal of Advanced Nursing*, *27*(6), 1242–1249.

Cloke, P., Philo, C., & Sadler, D. (1991). Structuration Theory: Anthony Giddens and the Bringing Together of Structure and Agency. *Cambridge Polity Press, Oxford*.

Coleman, J. S. (1994). *Foundations of Social Theory*. Harvard University Press.

Conde-Agudelo, A., Belizán, J. M., & Lammers, C. (2005). Maternal-perinatal morbidity and mortality associated with adolescent pregnancy in Latin America: Cross-sectional study. *American Journal of Obstetrics and Gynecology*, *192*(2), 342–349. https://doi.org/10.1016/j.ajog.2004.10.593

Cook, T. D., Shagle, S. C., & Degirmencioglu, S. M. (1997). Capturing social process for testing mediational models of neighborhood effects. In *Neighborhood poverty: Context and consequences for children*. Russell Sage Foundation Press.

Coolican, H. (2014). *Research methods and statistics in psychology, 6th ed.* (pp. xiii, 773). Psychology Press.

Costache, I. I., Miftode, E., Petris, O., Popa, A. D., Iliescu, D., & Eosefina, G. B. (2015). Associations between Area of residence and Cardiovascular risk. *Revista de Cercetare Si Interventie Sociala*, *49*, 68.

Craib, I. (1992). *Anthony Gidden's structuration*. Routledge a division of Routledge, Chapman and Hall Inc.

Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. *University of Chicago Legal Forum*, *1989*(1), 139.

Cressie, N. (2015). *Statistics for Spatial Data* (Revised). Wiley. https://www.wiley.com/en-gh/Statistics+for+Spatial+Data%2C+Revised+Edition-p-9781119114611

Cronk, L. (1989). Low Socioeconomic Status and Female-Biased Parental Investment: The Mukogodo Example. *American Anthropologist*, *91*(2), 414–429. https://doi.org/10.1525/aa.1989.91.2.02a00090

Crossan, F. (2003). Research philosophy: Towards an understanding. *Nurse Researcher (through 2013)*, *11*(1), 46.

CSDH. (2008). Closing the gap in a generation: Health equity through action on the social determinants of health. Final report of the Commission on Social Determinants of Health. *World Health Organization*, *10*(3), 253. https://doi.org/10.11606/issn.2316-9044.v10i3p253-266

Cummins, S., Curtis, S., Diez-Roux, A. V., & Macintyre, S. (2007a). Understanding and representing 'place' in health research: A relational approach. *Social Science & Medicine*, *65*(9), 1825–1838. https://doi.org/10.1016/j.socscimed.2007.05.036

Cummins, S., Curtis, S., Diez-Roux, A. V., & Macintyre, S. (2007b). Understanding and representing 'place' in health research: A relational approach. *Social Science & Medicine*, *65*(9), 1825–1838. https://doi.org/10.1016/j.socscimed.2007.05.036

Curtis, S., & Rees Jones, I. (1998). Is there a place for geography in the analysis of health inequality? *Sociology of Health & Illness*, *20*(5), 645–672.

Dake, F. A. A. (2012). Where do Overweight Women in Ghana Live? Answers from Exploratory Spatial Data Analysis. *Journal of Public Health in Africa*, *3*(1). https://doi.org/10.4081/jphia.2012.e12

Dangour, A. D., Watson, L., Cumming, O., Boisson, S., Che, Y., Velleman, Y., Cavill, S., Allen, E., & Uauy, R. (2013). Interventions to improve water quality and supply, sanitation and hygiene practices, and their effects on the nutritional status of children. *The Cochrane Database of Systematic Reviews*, *8*, CD009382. https://doi.org/10.1002/14651858.CD009382.pub2

Darteh, E. K. M., Acquah, E., & Kumi-Kyereme, A. (2014). Correlates of stunting among children in Ghana. *BMC Public Health*, *14*(1), 504. https://doi.org/10.1186/1471-2458-14-504

De Groot, R., Handa, S., Ragno, L. P., & Spadafora, T. (2017). Child Malnutrition, Consumption Growth, Maternal Care and Price Shocks: New Evidence from Northern Ghana. *Innocenti Working Papers 2017-01 UNICEF-IRC*. https://www.unicef-irc.org/publications/889-child-malnutrition-consumption-growth-maternal-care-and-price-shocks-new-evidence.html

De Koninck, M., & Pampalon, R. (2007). Living Environments and Health at the Local Level: The Case of Three Localities in the Québec City Region. *Canadian Journal of Public Health*, *98*(1), S45–S53. https://doi.org/10.1007/BF03403726

de Onis, M., & Blössner, M. (2003). The World Health Organization Global Database on Child Growth and Malnutrition: Methodology and applications. *International Journal of Epidemiology*, *32*(4), 518–526. https://doi.org/10.1093/ije/dyg099

de Onis, M., & Branca, F. (2016). Childhood stunting: A global perspective. *Maternal & Child Nutrition*, *12 Suppl 1*, 12–26. https://doi.org /10. 1111/mcn.12231

de Onis, M., Frongillo, E. A., & Blössner, M. (2000). Is malnutrition declining? : An analysis of changes in levels of child malnutrition since 1980. *Bulletin of the World Health Organization : The International Journal of Public Health 2000 ; 78(10) : 1222-1233*. https://apps.who. int/iris/handle/10665/57648

de Pee, S., Brinkman, H.-J., Webb, P., Godfrey, S., Darnton-Hill, I., Alderman, H., Semba, R. D., Piwoz, E., & Bloem, M. W. (2009). How to Ensure Nutrition Security in the Global Economic Crisis to Protect and Enhance Development of Young Children and Our Common Future. *The Journal of Nutrition*, *140*(1), 138S-142S. https://doi.org /10.3945/jn.109.112151

Debertin, D. L. (1996). A Comparison of Social Capital in Rural and Urban Settings. In *Staff Papers* (No. 159375; Staff Papers). University of Kentucky, Department of Agricultural Economics. https://ideas.repec.org/p/ags/ukysps/159375.html

Delpeuch, F., Traissac, P., Martin-Prével, Y., Massamba, J. P., & Maire, B. (2000). Economic crisis and malnutrition: Socioeconomic determinants of anthropometric status of preschool children and their mothers in an African urban area. *Public Health Nutrition*, *3*(1), 39–47. https://doi.org/10.1017/s1368980000000069

Denzin, N. K., & Lincoln, Y. S. (2005). *The Sage handbook of qualitative research*. Sage.

Desai, S., & Alva, S. (1998). Maternal education and child health: Is there a strong causal relationship? *Demography*, *35*(1), 71–81. https://doi.org/10.2307/3004028

Dewey, K. G., & Begum, K. (2011). Long-term consequences of stunting in early life. *Maternal & Child Nutrition*, *7 Suppl 3*, 5–18. https://doi.org/10.1111/j.1740-8709.2011.00349.x

Diehr, P. (1984). Small area statistics: Large statistical problems. *American Journal of Public Health*, *74*(4), 313–314. https://doi.org/10.2105/AJPH.74.4.313

Diez Roux, A. V. (2001). Investigating neighborhood and area effects on health. *American Journal of Public Health*, *91*(11), 1783–1789.

DuPlessis, H. M., Bell, R., & Richards, T. (1997). Adolescent pregnancy: Understanding the impact of age and race on outcomes. *The Journal of Adolescent Health: Official Publication of the Society for Adolescent*

Medicine, *20*(3), 187–197. https://doi.org/10.1016/S1054-139X(96)00174-7

Dzhamalov, R. G., Frolova, N. L., Safronova, T. I., Telegina, A. A., & Bugrov, A. A. (2015). Distribution and use of present-day water resources in European Russia. *Water Resources*, *42*(1), 28–37. https://doi.org/10.1134/S0097807815010030

Earls, F., & Carlson, M. (2001). The Social Ecology of Child Health and Well-Being. *Annual Review of Public Health*, *22*(1), 143–166. https://doi.org/10.1146/annurev.publhealth.22.1.143

El Badaoui, E., & Rebiere, T. (2013). Education, Informality, and Efficiency: A Matching Model for a Developing Economy. *Revue d'Economie Politique*, *123*, 423–441.

Elsmén, E., Hansen Pupp, I., & Hellström-Westas, L. (2004). Preterm male infants need more initial respiratory and circulatory support than female infants. *Acta Paediatrica (Oslo, Norway: 1992)*, *93*(4), 529–533. https://doi.org/10.1080/08035250410024998

Emamian, M. H., Fateh, M., Gorgani, N., & Fotouhi, A. (2014). Mother's education is the most important factor in socio-economic inequality of child stunting in Iran. *Public Health Nutrition*, *17*(9), 2010–2015. https://doi.org/10.1017/S1368980013002280

Emina, J. B.-O., Kandala, N.-B., Inungu, J., & Ye, Y. (2009). *The Effect of Maternal Education on Child Nutritional Status in the Democratic Republic of Congo*. 48.

Engell, R. E., & Lim, S. S. (2013). Does clean water matter? An updated meta-analysis of water supply and sanitation interventions and diarrhoeal diseases. *The Lancet*, *381*, S44. https://doi.org/10.1016/S0140-6736(13)61298-2

Espo, M., Kulmala, T., Maleta, K., Cullinan, T., Salin, M. L., & Ashorn, P. (2002). Determinants of linear growth and predictors of severe stunting during infancy in rural Malawi. *Acta Paediatrica (Oslo, Norway: 1992)*, *91*(12), 1364–1370. https://doi.org/10.1111/j.1651-2227.2002.tb02835.x

Everard, M. (2002). The use of freshwater science in policy development. *Freshwater Forum*, *18*, 13–26.

Ewusie, J. E., Beyene, J., Ahiadeke, C., & Hamid, J. S. (2017a). Malnutrition in Pre-school Children across Different Geographic Areas and Socio-Demographic Groups in Ghana. *Maternal and Child Health Journal*, *21*(4), 797–808. https://doi.org/10.1007/s10995-016-2173-z

Ewusie, J. E., Beyene, J., Ahiadeke, C., & Hamid, J. S. (2017b). Malnutrition in Pre-school Children across Different Geographic Areas and Socio-Demographic Groups in Ghana. *Maternal and Child Health Journal*, *21*(4), 797–808. https://doi.org/10.1007/s10995-016-2173-z

Fadare, O., Amare, M., Mavrotas, G., Akerele, D., & Ogunniyi, A. (2019). Mother's nutrition-related knowledge and child nutrition outcomes: Empirical evidence from Nigeria. *PloS One*, *14*(2), e0212775. https://doi.org/10.1371/journal.pone.0212775.

Fall, C. H. D., Sachdev, H. S., Osmond, C., Restrepo-Mendez, M. C., Victora, C., Martorell, R., Stein, A. D., Sinha, S., Tandon, N., Adair, L., Bas, I., Norris, S., & Richter, L. M. (2015). Association between maternal age at childbirth and child and adult outcomes in the offspring: A prospective study in five low-income and middle-income countries (COHORTS collaboration). *The Lancet. Global Health*, *3*(7), e341–e422. https://doi.org/10.1016/S2214-109X(15)00038-8

Fink, G., Günther, I., & Hill, K. (2011). The effect of water and sanitation on child health: Evidence from the demographic and health surveys 1986–2007. *International Journal of Epidemiology*, *40*(5), 1196–1204. https://doi.org/10.1093/ije/dyr102

Floch, J.-M., & Marcon, E. (2018). *Spatial distribution of points*.

Florida, R. (2018, December 13). The Lure of Urban Core Amenities Drives Gentrification and Increases Inequality. *Bloomberg.Com*. https://www.bloomberg.com/news/articles/2018-12-13/urban-amenities-lure-the-rich-income-inequality-follows

Folmer, H., & Oud, J. (2008). How to Get Rid of W: A Latent Variables Approach to Modelling Spatially Lagged Variables. *Environment and Planning A: Economy and Space*, *40*(10), 2526–2538. https://doi.org/10.1068/a4078

Ford, J. L., & Browning, C. R. (2014). Neighborhoods and infectious disease risk: Acquisition of chlamydia during the transition to young adulthood. *Journal of Urban Health*, *91*(1), 136–150.

Fotso, J.-C. (2006). Child health inequities in developing countries: Differences across urban and rural areas. *International Journal for Equity in Health*, *5*, 9. https://doi.org/10.1186/1475-9276-5-9

Fotso, J.-C. (2007). Urban–rural differentials in child malnutrition: Trends and socioeconomic correlates in sub-Saharan Africa. *Health & Place*, *13*(1), 205–223.

Frempong, R. B., & Annim, S. K. (2017). Dietary diversity and child malnutrition in Ghana. *Heliyon*, *3*(5). https://doi.org/10.1016/j.heliyon.2017.e00298

Frongillo, E. A., de Onis, M., & Hanson, K. M. (1997). Socioeconomic and demographic factors are associated with worldwide patterns of stunting and wasting of children. *The Journal of Nutrition*, *127*(12), 2302–2309. https://doi.org/10.1093/jn/127.12.2302

Frost, M. B., Forste, R., & Haas, D. W. (2005). Maternal education and child nutritional status in Bolivia: Finding the links. *Social Science & Medicine (1982)*, *60*(2), 395–407. https://doi.org/10.1016/j.socscimed.2004.05.010

Gang, I. N., Sen, K., & Yun, M.-S. (2002). Caste, Ethnicity and Poverty in Rural India. In *IZA Discussion Papers* (No. 629; IZA Discussion Papers). Institute of Labor Economics (IZA). https://ideas.repec.org/p/iza/izadps/dp629.html

Garcia, S., Sarmiento, O. L., Forde, I., & Velasco, T. (2013). Socio-economic inequalities in malnutrition among children and adolescents in Colombia: The role of individual-, household- and community-level characteristics. *Public Health Nutrition*, *16*(9), 1703–1718. https://doi.org/10.1017/S1368980012004090

Garenne, M. (2003). SEX DIFFERENCES IN HEALTH INDICATORS AMONG CHILDREN IN AFRICAN DHS SURVEYS. *Journal of Biosocial Science*, *35*(4), 601–614. https://doi.org/10.1017/S0021932003006047

Garnett, B. R., Masyn, K. E., Austin, S. B., Miller, M., Williams, D. R., & Viswanath, K. (2014). The intersectionality of discrimination attributes and bullying among youth: An applied latent class analysis. *Journal of Youth and Adolescence*, *43*(8), 1225–1239.

Gayawan, E., Adebayo, S. B., Komolafe, A. A., & Akomolafe, A. A. (2017). Spatial Distribution of Malnutrition among Children Under Five in Nigeria: A Bayesian Quantile Regression Approach. *Applied Spatial Analysis and Policy*, *12*(2), 229–254. https://doi.org/10.1007/s12061-017-9240-8

GDHS, G. D. and H. S. (2014). *Ghana Demographic and Health Survey 2014*. http://dhsprogram.com/publications/publication-FR307-DHS-Final-Reports.cfm

Ghana Statistical Service. (2014). *Multiple Indicator Cluster Survey, 2014: Monitoring the Situation of Children, Women, and Men; with an Enhanced Malaria Module and Biomarker*. Ghana Statistical Service.

GHS, G. H. S. (2014). *Newborn Care Programme | Programmes | Ghana Health Service*. https://www.ghanahealthservice.org/newborn/programme-cat.php?ghspid=3&ghscid=76

GHS, G. H. S. (2016). *National Nutrition Policy*. https://www.ghanahealthservice.org/downloads/National_Nutrition_Policy_JULY2016.pdf

Gibbs, C. M., Wendt, A., Peters, S., & Hogue, C. J. (2012). The impact of early age at first childbirth on maternal and infant health. *Paediatric and Perinatal Epidemiology*, *26 Suppl 1*, 259–284. https://doi.org/10.1111/j.1365-3016.2012.01290.x

Giddens, A. (1984). *The Constitution of Society*. University of California Press. https://www.ucpress.edu/book/9780520057289/the-constitution-of-society

Giddens, A. (1991). Structuration theory. *Past, Present and Future. In: Bryant, C. and Jary, D.(Eds.). Giddens' Theory of Structuration. A Critical Appreciation. London: Routledge*.

Gillman, M. W., Rich-Edwards, J. W., Rifas-Shiman, S. L., Lieberman, E. S., Kleinman, K. P., & Lipshultz, S. E. (2004). Maternal age and other predictors of newborn blood pressure. *The Journal of Pediatrics*, *144*(2), 240–245. https://doi.org/10.1016/j.jpeds.2003.10.064

Giroux, S. C. (2008). *Child stunting across schooling and fertility transitions: Evidence from sub-Saharan Africa*. Macro International.

Glaeser, E., Laibson, D., & Sacerdote, B. (2002). An Economic Approach to Social Capital. *Economic Journal*, *112*(483), 437–458.

Glewwe, P. (1999). Why Does Mother's Schooling Raise Child Health in Developing Countries? Evidence from Morocco. *The Journal of Human Resources*, *34*(1), 124–159. JSTOR. https://doi.org/10.2307/146305

Godbout, J. T., & Caille, A. (1998). The World of the Gift. *McGill-Queen's University Press*. http://web.mit.edu/allanmc/www/godbout1.pdf

Godfrey, S., Labhasetwar, P., Wate, S., & Pimpalkar, S. (2011). How safe are the global water coverage figures? Case study from Madhya Pradesh, India. *Environmental Monitoring and Assessment*, *176*(1–4), 561–574. https://doi.org/10.1007/s10661-010-1604-3

Grannis, R. (1998). The importance of trivial streets: Residential streets and residential segregation. *American Journal of Sociology*, *103*(6), 1530–1564.

Grantham-McGregor, S., Cheung, Y. B., Cueto, S., Glewwe, P., Richter, L., & Strupp, B. (2007). Developmental potential in the first 5 years for children in developing countries. *The Lancet*, *369*(9555), 60–70. https://doi.org/10.1016/S0140-6736(07)60032-4

Gray, A. M. (1982). Inequalities in health. The Black Report: A summary and comment. *International Journal of Health Services: Planning, Administration, Evaluation*, *12*(3), 349–380. https://doi.org/10.2190 /XXMM-JMQU-2A7Y-HX1E

Greenaway, E. S., Leon, J., & Baker, D. P. (2012). Understanding the association between maternal education and use of health services in Ghana: Exploring the role of health knowledge. *Journal of Biosocial Science*, *44*(6), 733–747. https://doi.org/10.1017/S0021932012000041

Grépin, K. A., & Bharadwaj, P. (2015). Maternal education and child mortality in Zimbabwe. *Journal of Health Economics*, *44*, 97–117. https://doi.org/10.1016/j.jhealeco.2015.08.003

Grossman, M. (1972). The Demand for Health: A Theoretical and Empirical Investigation. *National Bureau of Ecnomic Research*. https://www.nber.org/books/gros72-1

Güneş, P. M. (2015). The role of maternal education in child health: Evidence from a compulsory schooling law. *Economics of Education Review*, *47*, 1–16. https://doi.org/10.1016/j.econedurev.2015.02.008

Hair, J., Black, W., Babin, B., & Anderson, R. (2010). *Multivariate Data Analysis: A Global Perspective* (7th ed.).

Hancock, A.-M. (2007a). When Multiplication Doesn't Equal Quick Addition: Examining Intersectionality as a Research Paradigm. *Perspectives on Politics*, *5*(1), 63–79. https://doi.org/10.1017/S1537592707070065

Hancock, A.-M. (2007b). Intersectionality as a Normative and Empirical Paradigm. *Politics & Gender*, *3*(2), 248–254. https://doi.org/10.1017/S1743923X07000062

Hankivsky, O., & Christoffersen, A. (2008). Intersectionality and the determinants of health: A Canadian perspective. *Critical Public Health*, *18*(3), 271–283. https://doi.org/10.1080/09581590802294296

Hankivsky, O., Doyal, L., Einstein, G., Kelly, U., Shim, J., Weber, L., & Repta, R. (2017). The odd couple: Using biomedical and intersectional approaches to address health inequities. *Global Health Action*, *10*(sup2), 1326686. https://doi.org/10.1080/16549716.2017.1326686

Hatt, L. E., & Waters, H. R. (2006). Determinants of child morbidity in Latin America: A pooled analysis of interactions between parental education and economic status. *Social Science & Medicine (1982)*, *62*(2), 375–386. https://doi.org/10.1016/j.socscimed.2005.06.007

Haynes, R., Daras, K., Reading, R., & Jones, A. (2007). Modifiable neighbourhood units, zone design and residents' perceptions. *Health & Place*, *13*(4), 812–825. https://doi.org/10.1016/j.healthplace.2007.01.002

Headey, D., & Palloni, G. (2019). Water, Sanitation, and Child Health: Evidence From Subnational Panel Data in 59 Countries. *Demography*, *56*(2), 729–752. https://doi.org/10.1007/s13524-019-00760-y

Higgins, J. P. T., Altman, D. G., Gøtzsche, P. C., Jüni, P., Moher, D., Oxman, A. D., Savovic, J., Schulz, K. F., Weeks, L., Sterne, J. A. C., Cochrane Bias Methods Group, & Cochrane Statistical Methods Group. (2011). The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ (Clinical Research Ed.)*, *343*, d5928. https://doi.org/10.1136/bmj.d5928

Hines, R., Markossian, T., Johnson, A., Dong, F., & Bayakly, R. (2014). Geographic residency status and census tract socioeconomic status as determinants of colorectal cancer outcomes. *American Journal of Public Health*, *104*(3), e63–e71.

Hobcraft, J. (1993). Women's education, child welfare and child survival: A review of the evidence. *Health Transition Review: The Cultural, Social, and Behavioural Determinants of Health*, *3*(2), 159–175.

Howell, K. E. (2012). *An introduction to the philosophy of methodology*. Sage.

Hoyt, L. T., Kushi, L. H., Leung, C. W., Nickleach, D. C., Adler, N., Laraia, B. A., Hiatt, R. A., & Yen, I. H. (2014). Neighborhood influences on girls' obesity risk across the transition to adolescence. *Pediatrics*, *134*(5), 942–949.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Hughes, J. (1994). *The Philosophy of Social Research. Essex, Longman Press*.

Humphreys, K., & Carr-Hill, R. (1991). Area variations in health outcomes: Artefact or ecology. *International Journal of Epidemiology*, *20*(1), 251–258.

Imai, K., Annim, S. K., Gaiha, R., & Kulkarni, V. S. (2012). Does Women's Empowerment Reduce Prevalence of Stunted and Underweight Children in Rural India? *The University of Manchester, Economics, Discussion Paper Series, EDP-1209*. http://www.socialsciences.manchester.ac.uk/disciplines/economics/research/discussionpapers/pdf

Islam, M. K., Gerdtham, U.-G., Gullberg, B., Lindström, M., & Merlo, J. (2008). Social capital externalities and mortality in Sweden. *Economics & Human Biology*, *6*(1), 19–42. https://doi.org/10.1016/j.ehb.2007.09.004

Jackson, A. A., Ashworth, A., & Khanum, S. (2006). Improving child survival: Malnutrition Task Force and the paediatrician's responsibility. *Archives of Disease in Childhood*, *91*(8), 706–710. https://doi.org/10.1136/adc.2006.095596

Jejeboy, S. (1992). *Women's Education, Fertility and the Proximate Determinants of Fertility*. Expert Group Meeting on Population and Women, Gaborone, Botswana.

Jia, P., Anderson, J. D., Leitner, M., & Rheingans, R. (2016). High-Resolution Spatial Distribution and Estimation of Access to Improved Sanitation in Kenya. *PLOS ONE*, *11*(7), e0158490. https://doi.org/10.1371/journal.pone.0158490

Johnson, A. M., Hines, R. B., Johnson III, J. A., & Bayakly, A. R. (2014). Treatment and survival disparities in lung cancer: The effect of social environment and place of residence. *Lung Cancer*, *83*(3), 401–407.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, *33*(7), 14–26.

Källestål, C., Blandón, E. Z., Peña, R., Peréz, W., Contreras, M., Persson, L.-Å., Sysoev, O., & Selling, K. E. (2019). Assessing the multiple dimensions of poverty. Data mining approaches to the 2004-14 Health and Demographic Surveillance System in Cuatro Santos, Nicaragua. *BioRxiv*, 593426. https://doi.org/10.1101/593426

Kamanda, M., Madise, N., & Schnepf, S. (2016). Does living in a community with more educated mothers enhance children's school attendance? Evidence from Sierra Leone. *International Journal of Educational Development*, *46*, 114–124. https://doi.org/10. 1016/j.ijedudev.2015. 09.008

Kanakoudis, V., Papadopoulou, A., Tsitsifli, S., Čencur Curk, B., Karleuša, B., Matić, B., Altran, E., & Banovec, P. (2017). Policy recommendation for drinking water supply cross-border networking in the Adriatic region. *Journal of Water Supply: Research and*

Technology. AQUA, *66*(7), 489–508. https://doi.org/10.2166/aqua.2017.079

Kanakoudis, V., Tsitsifli, S., Papadopoulou, A., Cencur Curk, B., & Karleusa, B. (2017). Water resources vulnerability assessment in the Adriatic Sea region: The case of Corfu Island. *Environmental Science and Pollution Research*, *24*(25), 20173–20186. https://doi.org/10.1007/s11356-017-9732-8

Kanakoudis, V., Tsitsifli, S., Papadopoulou, A., Curk, B. C., & Karleusa, B. (2016). Estimating the Water Resources Vulnerability Index in the Adriatic Sea Region. *Procedia Engineering*, *162*, 476–485. https://doi.org/10.1016/j.proeng.2016.11.091

Kandala, N.-B., Ji, C., Stallard, N., Stranges, S., & Cappuccio, F. P. (2007). Spatial Analysis of Risk Factors for Childhood Morbidity in Nigeria. *The American Journal of Tropical Medicine and Hygiene*, *77*(4), 770–779. https://doi.org/10.4269/ajtmh.2007.77.770

Kandala, N.-B., Madungu, T. P., Emina, J. B. O., Nzita, K. P. D., & Cappuccio, F. P. (2011). Malnutrition among children under the age of five in the Democratic Republic of Congo (DRC): Does geographic location matter? *BMC Public Health*, *11*, 261. https://doi.org/10.1186/1471-2458-11-261

Kang, Y., Aguayo, V. M., Campbell, R. K., Dzed, L., Joshi, V., Waid, J. L., Gupta, S. D., Haselow, N. J., & West, K. P. (2018). Nutritional status and risk factors for stunting in preschool children in Bhutan. *Maternal & Child Nutrition*, *14*(S4), e12653. https://doi.org/10.1111/mcn.12653

Kanmiki, E. W., Bawah, A. A., Agorinya, I., Achana, F. S., Awoonor-Williams, J. K., Oduro, A. R., Phillips, J. F., & Akazili, J. (2014). Socio-economic and demographic determinants of under-five mortality in rural northern Ghana. *BMC International Health and Human Rights, 14*, 24. https://doi.org/10.1186/1472-698X-14-24

Kapilashrami, A., & Hankivsky, O. (2018). Intersectionality and why it matters to global health. *Lancet (London, England)*, *391*(10140), 2589–2591. https://doi.org/10.1016/S0140-6736(18)31431-4

Karolinska Institutet. (2019, September 9). *Why people gain weight as they get older*. ScienceDaily. https://www.sciencedaily.com/releases/2019/09/190909193211.htm

Kawachi, I., Subramanian, S. V., & Almeida-Filho, N. (2002). A glossary for health inequalities. *Journal of Epidemiology and Community Health*, *56*(9), 647–652. https://doi.org/10.1136/jech.56.9.647

Kawachi, Ichiro, & Berkman, L. F. (2003). *Neighborhoods and health*. Oxford University Press.

Keats, A. (2018). Women's schooling, fertility, and child health outcomes: Evidence from Uganda's free primary education program. *Journal of Development Economics*, *135*(C), 142–159.

Kelejian, H. H., & Prucha, I. R. (1998). A Generalized Spatial Two-Stage Least Squares Procedure for Estimating a Spatial Autoregressive Model with Autoregressive Disturbances. *The Journal of Real Estate Finance and Economics*, *17*(1), 99–121. https://doi.org/10.1023/A:1007707430416

Kelejian, H. H., & Robinson, D. P. (1993). A Suggested Method of Estimation for Spatial Interdependent Models with Autocorrelated Errors, and an Application to a County Expenditure Model. *Papers in Regional Science*, *72*(3), 297–312. https://doi.org/10.1111/j.1435-5597.1993.tb01878.x

Kellogg, W. A. (1997). Metropolitan Growth and the Local Role in Surface Water Resource Protection in the Lake Erie Basin. *Journal of Great Lakes Research*, *23*(3), 270–285. https://doi.org/10.1016/S0380-1330(97)70911-0

Kelly, U. A. (2009). Integrating intersectionality and biomedicine in health disparities research. *ANS. Advances in Nursing Science*, *32*(2), E42-56. https://doi.org/10.1097/ANS.0b013e3181a3b3fc

Kenny, L. C., Lavender, T., McNamee, R., O'Neill, S. M., Mills, T., & Khashan, A. S. (2013). Advanced maternal age and adverse pregnancy outcome: Evidence from a large contemporary cohort. *PloS One*, *8*(2), e56583. https://doi.org/10.1371/journal.pone.0056583

Kerac, M., Bunn, J., Chagaluka, G., Bahwere, P., Tomkins, A., Collins, S., & Seal, A. (2014). Follow-up of post-discharge growth and mortality after treatment for severe acute malnutrition (FuSAM study): A prospective cohort study. *PloS One*, *9*(6), e96030. https://doi.org/10.1371/journal.pone.0096030

Khan, A. J., Hussain, H., Omer, S. B., Chaudry, S., Ali, S., Khan, A., Yasin, Z., Khan, I. J., Mistry, R., Baig, I. Y., White, F., Moulton, L. H., & Halsey, N. A. (2009). High incidence of childhood pneumonia at high altitudes in Pakistan: A longitudinal cohort study. *Bulletin of the World*

Health Organization, *87*(3), 193–199. https://doi.org/10.2471/BLT.07.048264

Khan, J., & Mohanty, S. K. (2018). Spatial heterogeneity and correlates of child malnutrition in districts of India. *BMC Public Health*, *18*(1), 1027. https://doi.org/10.1186/s12889-018-5873-z

Khan, S., Zaheer, S., & Safdar, N. F. (2019). Determinants of stunting, underweight and wasting among children < 5 years of age: Evidence from 2012-2013 Pakistan demographic and health survey. *BMC Public Health*, *19*(1), 358. https://doi.org/10.1186/s12889-019-6688-2

Kikafunda, J. K., Walker, A. F., Collett, D., & Tumwine, J. K. (1998). Risk Factors for Early Childhood Malnutrition in Uganda. *Pediatrics*, *102*(4), e45–e45. https://doi.org/10.1542/peds.102.4.e45

Kilbride, H. W., & Daily, D. K. (1998). Survival and subsequent outcome to five years of age for infants with birth weights less than 801 grams born from 1983 to 1989. *Journal of Perinatology: Official Journal of the California Perinatal Association*, *18*(2), 102–106.

Kraak, V. I., Harrigan, P. B., Lawrence, M., Harrison, P. J., Jackson, M. A., & Swinburn, B. (2012). Balancing the benefits and risks of public-private partnerships to address the global double burden of malnutrition. *Public Health Nutrition*, *15*(3), 503–517. https://doi.org/10.1017/S1368980011002060

Kroupina, M. G., Toemen, L., Aidjanov, M. M., Georgieff, M., Hearst, M. O., Himes, J. H., Johnson, D. E., Miller, B. S., Syzdykova, A. M., Sharmanov, T. S., & Spoon Foundation Research team. (2015). Predictors of Developmental Status in Young Children Living in

Institutional Care in Kazakhstan. *Maternal and Child Health Journal*, *19*(6), 1408–1416. https://doi.org/10.1007/s10995-014-1647-0

LaVela, S. L., Smith, B., Weaver, F. M., & Miskevics, S. A. (2004). Geographical proximity and health care utilization in veterans with SCI&D in the USA. *Social Science & Medicine*, *59*(11), 2387–2399. https://doi.org/10.1016/j.socscimed.2004.06.033

Lawlor, D. A., Mortensen, L., & Andersen, A.-M. N. (2011). Mechanisms underlying the associations of maternal age with adverse perinatal outcomes: A sibling study of 264 695 Danish women and their firstborn offspring. *International Journal of Epidemiology*, *40*(5), 1205–1214. https://doi.org/10.1093/ije/dyr084

Lawlor, D. A., Najman, J. M., Sterne, J., Williams, G. M., Ebrahim, S., & Davey Smith, G. (2004). Associations of parental, birth, and early life characteristics with systolic blood pressure at 5 years of age: Findings from the Mater-University study of pregnancy and its outcomes. *Circulation*, *110*(16), 2417–2423. https://doi.org/10.1161/01.CIR.0000145165.80130.B5

LeGrand, T. K., & Mbacké, C. S. (1993). Teenage pregnancy and child health in the urban Sahel. *Studies in Family Planning*, *24*(3), 137–149.

Lemon, G. H., & Krutchkoff, R. G. (1969). An empirical Bayes smoothing technique. *Biometrika*, *56*(2), 361–365. https://doi.org/10.1093/biomet/56.2.361.

Leslie, J., Ciemins, E., & Essama, S. B. (1997). Female Nutritional Status across the Life-Span in Sub-Saharan Africa. 1. Prevalence Patterns. *Food and Nutrition Bulletin*, *18*(1), 1–22. https://doi.org/10. 1177/ 156482659701800105

Lim, S. S., Vos, T., Flaxman, A. D., Danaei, G., Shibuya, K., Adair-Rohani, H., Amann, M., Anderson, H. R., Andrews, K. G., Aryee, M., Atkinson, C., Bacchus, L. J., Bahalim, A. N., Balakrishnan, K., Balmes, J., Barker-Collo, S., Baxter, A., Bell, M. L., Blore, J. D., … Ezzati, M. (2012). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: A systematic analysis for the Global Burden of Disease Study 2010. *Lancet*, *380*(9859), 2224–2260. https://doi.org/ 10.1016/S0140-6736(12)61766-8

Lipsk, S., Stephenson, P. A., Koepsell, T. D., Gloyd, S. S., Lopez, J.-L., & Bain, C. E. (2016). Breastfeeding and Weaning Practices in Rural Mexico: *Nutrition and Health*. https://doi.org/10.1177/02601060940 0900402

Liu, H., Rizzo, J. A., & Fang, H. (2015). Urban-rural disparities in child nutrition-related health outcomes in China: The role of hukou policy. *BMC Public Health*, *15*(1), 1159.

Lucas, R. E. (1988). On the Mechanics of Economic Development. *Journal of Monetary Economics*, *22*(1), 3–42.

Ludwig, J., Duncan, G. J., Gennetian, L. A., Katz, L. F., Kessler, R. C., Kling, J. R., & Sanbonmatsu, L. (2012). Neighborhood Effects on the Long-Term Well-Being of Low-Income Adults. *Science*, *337*(6101), 1505–1510. https://doi.org/10.1126/science.1224648

Mackenbach, J. P., Stirbu, I., Roskam, A.-J. R., Schaap, M. M., Menvielle, G., Leinsalu, M., & Kunst, A. E. (2008). Socioeconomic inequalities in health in 22 European countries. *New England Journal of Medicine*, *358*(23), 2468–2481.

Maggi, S., Irwin, L. J., Siddiqi, A., & Hertzman, C. (2010). The social determinants of early child development: An overview. *Journal of Paediatrics and Child Health*, *46*(11), 627–635. https://doi.org/10.1111/j.1440-1754.2010.01817.x

Markovitz, B. P., Cook, R., Flick, L. H., & Leet, T. L. (2005). Socioeconomic factors and adolescent pregnancy outcomes: Distinctions between neonatal and post-neonatal deaths? *BMC Public Health*, *5*, 79. https://doi.org/10.1186/1471-2458-5-79

Marmot, M., Allen, J., Bell, R., Bloomer, E., & Goldblatt, P. (2012). WHO European review of social determinants of health and the health divide. *The Lancet*, *380*(9846), 1011–1029. https://doi.org/10.1016/S0140-6736(12)61228-8

Marmot, M. G., & McDowall, M. E. (1986). Mortality decline and widening social inequalities. *The Lancet*, *328*(8501), 274–276.

Marshall, A. (1890). *Principles of Economics*. Macmillan.

Matsungo, T. M., Kruger, H. S., Faber, M., Rothman, M., & Smuts, C. M. (2017). The prevalence and factors associated with stunting among infants aged 6 months in a peri-urban South African community. *Public Health Nutrition, 20*(17), 3209–3218. https://doi.org/10 .1017/S 1368980017002087

McCall, L. (2005). The Complexity of Intersectionality. *Signs: Journal of Women in Culture and Society*, *30*(3), 1771–1800. https://doi. org/10.1086/426800

McKenna, C. G., Bartels, S. A., Pablo, L. A., & Walker, M. (2019). Women's decision-making power and undernutrition in their children under age five in the Democratic Republic of the Congo: A cross-sectional study. *PLOS ONE*, *14*(12), e0226041. https://doi.org /10.1371/journal.pone. 0226041

McNeish, D. M. (2014). Analyzing Clustered Data with OLS Regression: The Effect of a Hierarchical Data Structure. *Multiple Linear Regression Viewpoints, 40*(1), 6.

Menon, P., Headey, D., Avula, R., & Nguyen, P. H. (2018). Understanding the geographical burden of stunting in India: A regression-decomposition analysis of district-level data from 2015-16. *Maternal & Child Nutrition, 14*(4), e12620. https://doi.org/10.1111/mcn.12620

Messner, S. F., Anselin, L., Baller, R. D., Hawkins, D. F., Deane, G., & Tolnay, S. E. (1999). The Spatial Patterning of County Homicide Rates: An Application of Exploratory Spatial Data Analysis. *Journal of Quantitative Criminology, 15*(4), 423–450.

Michaelis, R., Asenbauer, C., Buchwald-Saal, M., Haas, G., & Krägeloh-Mann, I. (1993). Transitory neurological findings in a population of at risk infants. *Early Human Development*, *34*(1–2), 143–153. https://doi.org/10.1016/0378-3782(93)90049-z

Milanovic, B. (2010). *The haves and the have-nots: A brief and idiosyncratic history of global inequality*. Basic Books (AZ).

Miller, L. C., Joshi, N., Lohani, M., Rogers, B., Mahato, S., Ghosh, S., & Webb, P. (2017). Women's education level amplifies the effects of a livelihoods-based intervention on household wealth, child diet, and child growth in rural Nepal. *International Journal for Equity in Health*, *16*. https://doi.org/10.1186/s12939-017-0681-0

Murray, C. J., Gakidou, E. E., & Frenk, J. (1999). Health inequalities and social group differences: What should we measure? *Bulletin of the World Health Organization*, *77*(7), 537.

Nakamura, H., Ikeda, N., Stickley, A., Mori, R., & Shibuya, K. (2011). Achieving MDG 4 in sub-Saharan Africa: What has contributed to the accelerated child mortality decline in Ghana? *PloS One*, *6*(3), e17774. https://doi.org/10.1371/journal.pone.0017774

National Research Council (US), & Institute of Medicine (US). (2004). Children's Health: A New Conceptual Framework. In *Children's Health, The Nation's Wealth: Assessing and Improving Child Health*. National Academies Press (US). https://www.ncbi.nlm.nih.gov/books/NBK92198/

New Districts and Nominated DCEs. (2013, March 5). Http://Ghanadistricts .Com.https://web.archive.org/web/20130305161824/http://ghanadistricts.com/pdfs/newcreateddistricts.pdf

Newburn-Cook, C. V., & Onyskiw, J. E. (2005). Is older maternal age a risk factor for preterm birth and fetal growth restriction? A systematic review. *Health Care for Women International*, *26*(9), 852–875. https://doi.org/10.1080/07399330500230912

Ngare, D. K., & Muttunga, J. N. (1999). Prevalence of malnutrition in Kenya. *East African Medical Journal*, *76*(7), 376–380.

Ngowa, J. D. K., Ngassam, A.-N., Dohbit, J. S., Nzedjom, C., & Kasia, J. M. (2013). Pregnancy outcome at advanced maternal age in a group of African women in two teaching Hospitals in Yaounde, Cameroon. *The Pan African Medical Journal*, *14*, 134. https://doi.org/10.11604/pamj.2013.14.134.2315

Niermeyer, S., Andrade Mollinedo, P., & Huicho, L. (2009). Child health and living at high altitude. *Archives of Disease in Childhood*, *94*(10), 806–811. https://doi.org/10.1136/adc.2008.141838

Novignon, J., Aboagye, E., Agyemang, O. S., & Aryeetey, G. (2015). Socioeconomic-related inequalities in child malnutrition: Evidence from the Ghana multiple indicator cluster survey. *Health Economics Review*, *5*(1), 34. https://doi.org/10.1186/s13561-015-0072-4

Ntshebe, O., Channon, A. A., & Hosegood, V. (2019). Household composition and child health in Botswana. *BMC Public Health*, *19*(1), 1621. https://doi.org/10.1186/s12889-019-7963-y

Nygren, K. G., & Olofsson, A. (2014). Intersectional Approaches in Health-Risk Research: A Critical Review. *Sociology Compass*, *8*(9), 1112–1126. https://doi.org/10.1111/soc4.12176

Nyunt, M. S. Z., Shuvo, F. K., Eng, J. Y., Yap, K. B., Scherer, S., Hee, L. M., Chan, S. P., & Ng, T. P. (2015). Objective and subjective measures of neighborhood environment (NE): Relationships with transportation physical activity among older persons. *International Journal of Behavioral Nutrition and Physical Activity*, *12*(1), 108. https://doi.org/10.1186/s12966-015-0276-3

O'Campo, P., & O'Brien Caughy, M. (2006). Measures of residential community contexts. In *Methods in Social Epidemiology* (2nd Edition). John Wiley & Sons, Inc. https://www.wiley.com/en-us/Methods+in+Social+Epidemiology%2C+2nd+Edition-p-9781118505595

O'Campo, P., Wheaton, B., Nisenbaum, R., Glazier, R. H., Dunn, J. R., & Chambers, C. (2015). The Neighbourhood Effects on Health and Well-being (NEHW) study. *Health & Place*, *31*, 65–74. https://doi.org/10.1016/j.healthplace.2014.11.001

Oki D., Tsuji S., & Mushiaki T. (2003). Global Water Cycle and World Water Resources. *Membrane*, *28*(5), 206–214. https://doi.org/10.5360/membrane.28.206

Oktaria, V., Lee, K. J., Bines, J. E., Watts, E., Satria, C. D., Atthobari, J., Nirwati, H., Kirkwood, C. D., Soenarto, Y., & Danchin, M. H. (2017). Nutritional status, exclusive breastfeeding and management of acute respiratory illness and diarrhea in the first 6 months of life in infants from two regions of Indonesia. *BMC Pediatrics*, *17*(1), 211. https://doi.org/10.1186/s12887-017-0966-x

Oud, J. H. L., & Folmer, H. (2008). A Structural Equation Approach to Models with Spatial Dependence. *Geographical Analysis*, *40*(2), 152–166. https://doi.org/10.1111/j.1538-4632.2008.00717.x

Paranjothy, S., Broughton, H., Adappa, R., & Fone, D. (2009). Teenage pregnancy: Who suffers? *Archives of Disease in Childhood*, *94*(3), 239–245. https://doi.org/10.1136/adc.2007.115915

Park, R. E. (1915). The city: Suggestions for the investigation of human behavior in the city environment. *American Journal of Sociology*, *20*(5), 577–612.

Pedraza, D. F., & de Menezes, T. N. (2014). [Risk factors of stunting in preschool children: A case-control study]. *Ciencia & Saude Coletiva*, *19*(5), 1495–1502. https://doi.org/10.1590/1413-81232014195.21702013

Pence, H. E. (2014). What is Big Data and Why is it Important?: *Journal of Educational Technology Systems*. https://doi.org/10.2190/ET.43.2.d

Phillips, D. C., & Burbules, N. C. (2000). *Postpositivism and educational research*. Rowman & Littlefield.

Pradhan, M., Sahn, D. E., & Younger, S. D. (2003). Decomposing world health inequality. *Journal of Health Economics*, *22*(2), 271–293. https://doi.org/10.1016/S0167-6296(02)00123-6

Prickett, K. C., & Augustine, J. M. (2016). Maternal Education and Investments in Children's Health. *Journal of Marriage and the Family*, *78*(1), 7–25. https://doi.org/10.1111/jomf.12253

Priest, N., Paradies, Y., Trenerry, B., Truong, M., Karlsen, S., & Kelly, Y. (2013). A systematic review of studies examining the relationship between reported racism and health and wellbeing for children and young people. *Social Science & Medicine (1982)*, *95*, 115–127. https://doi.org/10.1016/j.socscimed.2012.11.031

Prins, N., & Kingdom, F. A. A. (2018). Applying the Model-Comparison Approach to Test Specific Research Hypotheses in Psychophysical Research Using the Palamedes Toolbox. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.01250

Productivity Commission. (2003). *Social Capital: Reviewing the concept and its policy implications : Commission research paper.* AusInfo.

Qasem, W., Fenton, T., & Friel, J. (2015). Age of introduction of first complementary feeding for infants: A systematic review. *BMC Pediatrics*, *15*(1), 107. https://doi.org/10.1186/s12887-015-0409-5

Quansah, E., Ohene, L. A., Norman, L., Mireku, M. O., & Karikari, T. K. (2016). Social Factors Influencing Child Health in Ghana. *PLOS ONE*, *11*(1), e0145401. https://doi.org/10.1371/journal.pone.0145401

Rakotomanana, H., Gates, G. E., Hildebrand, D., & Stoecker, B. J. (2017). Determinants of stunting in children under 5 years in Madagascar. *Maternal & Child Nutrition*, *13*(4), e12409. https://doi.org/10.1111/mcn.12409

Raudenbush, S. W., & Sampson, R. J. (1999). Ecometrics: Toward a Science of Assessing Ecological Settings, with Application to the Systematic Social Observation of Neighborhoods. *Sociological Methodology*, *29*(1), 1–41. https://doi.org/10.1111/0081-1750.00059

Rehman, A. M., Gladstone, B. P., Verghese, V. P., Muliyil, J., Jaffar, S., & Kang, G. (2009). Chronic growth faltering amongst a birth cohort of Indian children begins prior to weaning and is highly prevalent at three years of age. *Nutrition Journal*, *8*(1), 44. https://doi.org/10.1186/1475-2891-8-44

Reiner, R. C., Wiens, K. E., Deshpande, A., Baumann, M. M., Lindstedt, P. A., Blacker, B. F., Troeger, C. E., Earl, L., Munro, S. B., Abate, D., Abbastabar, H., Abd-Allah, F., Abdelalim, A., Abdollahpour, I., Abdulkader, R. S., Abebe, G., Abegaz, K. H., Abreu, L. G., Abrigo, M. R. M., … Hay, S. I. (2020). Mapping geographical inequalities in childhood diarrhoeal morbidity and mortality in low-income and middle-income countries, 2000–17: Analysis for the Global Burden of Disease Study 2017. *The Lancet*, *395*(10239), 1779–1801. https://doi.org/10.1016/S0140-6736(20)30114-8

Restrepo-Méndez, M. C., Barros, A. J. D., Santos, I. S., Menezes, A. M. B., Matijasevich, A., Barros, F. C., & Victora, C. G. (2011). Childbearing during adolescence and offspring mortality: Findings from three population-based cohorts in southern Brazil. *BMC Public Health*, *11*, 781. https://doi.org/10.1186/1471-2458-11-781

Reyes, H., Pérez-Cuevas, R., Sandoval, A., Castillo, R., Santos, J. I., Doubova, S. V., & Gutiérrez, G. (2004). The family as a determinant of stunting in children living in conditions of extreme poverty: A case-control study. *BMC Public Health*, *4*(1), 57. https://doi.org/10.1186/1471-2458-4-57

Ricci, J. A., & Becker, S. (1996). Risk factors for wasting and stunting among children in Metro Cebu, Philippines. *The American Journal of Clinical Nutrition*, *63*(6), 966–975. https://doi.org/10.1093/ajcn/63.6.966

Richards, G. (2017). *Big Data and Analytics Applications in Government: Current Practices and Future Opportunities*. CRC Press.

Rikimaru, T., Yartey, J. E., Taniguchi, K., Kennedy, D. O., & Nkrumah, F. K. (1998). Risk factors for the prevalence of malnutrition among urban children in Ghana. *Journal of Nutritional Science and Vitaminology*, *44*(3), 391–407. https://doi.org/10.3177/jnsv.44.391

Roberts, R. J., Leary, S. D., Smith, G. D., Ness, A. R., & ALSPAC Study Team. (2005). Maternal age in pregnancy and offspring blood pressure in childhood in the Avon Longitudinal Study of Parents and Children (ALSPAC). *Journal of Human Hypertension*, *19*(11), 893–900. https://doi.org/10.1038/sj.jhh.1001915

Rose, G. (2001). Sick individuals and sick populations. *International Journal of Epidemiology*, *30*(3), 427–432. https://doi.org/10.1093/ije/30.3.427

Rosenzweig, M., & Schultz, T. (1989). Schooling, Information and Nonmarket Productivity: Contraceptive Use and Its Effectiveness. *International Economic Review*, *30*(2), 457–477.

Rushton, G., & Lolonis, P. (1996). Exploratory Spatial Analysis of Birth Defect Rates in an Urban Population. *Statistics in Medicine*, *15*(7–9), 717–726. https://doi.org/10.1002/(SICI)1097-0258(19960415)15:7/9<717::AID-SIM243>3.0.CO;2-0

Rutter, M. (1987). Psychosocial resilience and protective mechanisms. *The American Journal of Orthopsychiatry*, *57*(3), 316–331. https://doi.org/10.1111/j.1939-0025.1987.tb03541.x

Ryan, G. (2018). Introduction to positivism, interpretivism and critical theory. *Nurse Researcher*, *25*(4), 41–49.

Sampson, R. J. (2012). Moving and the Neighborhood Glass Ceiling. *Science*, *337*(6101), 1464–1465. https://doi.org/10.1126/science.1227881

Sampson, R. J., Morenoff, J. D., & Gannon-Rowley, T. (2002). Assessing 'Neighborhood Effects': Social Processes and New Directions in Research. *Annual Review of Sociology*, *28*, 443–478. JSTOR.

Scherbaum, V., & Srour, M. L. (2016). The Role of Breastfeeding in the Prevention of Childhood Malnutrition. *World Review of Nutrition and Dietetics*, *115*, 82–97. https://doi.org/10.1159/000442075

Scholl, T. O., & Hediger, M. L. (1993). A review of the epidemiology of nutrition and adolescent pregnancy: Maternal growth during pregnancy and its effect on the fetus. *Journal of the American College of Nutrition*, *12*(2), 101–107. https://doi.org/10.1080/07315724.1993.10718289

Semba, R. D. (2016). The Rise and Fall of Protein Malnutrition in Global Health. *Annals of Nutrition & Metabolism*, *69*(2), 79–88. https://doi.org/10.1159/000449175

Sen, A. (1983). Poor, relatively speaking. *Oxford Economic Papers*, *35*(2), 153–169.

Shaheed, A., Orgill, J., Montgomery, M. A., Jeuland, M. A., & Brown, J. (2014). Why “improved” water sources are not always safe. *Bulletin of the World Health Organization*, *92*(4), 283–289. https://doi.org/10.2471/BLT.13.119594

Sharkey, P., & Faber, J. W. (2014). Where, When, Why, and For Whom Do Residential Contexts Matter? Moving Away from the Dichotomous Understanding of Neighborhood Effects. *Annual Review of Sociology*, *40*(1), 559–579. https://doi.org/10.1146/annurev-soc-071913-043350

Sharma, V., Katz, J., Mullany, L. C., Khatry, S. K., LeClerq, S. C., Shrestha, S. R., Darmstadt, G. L., & Tielsch, J. M. (2008). Young maternal age and the risk of neonatal mortality in rural Nepal. *Archives of Pediatrics & Adolescent Medicine*, *162*(9), 828–835. https://doi.org/10.1001/archpedi.162.9.828

Shih, F.-J. (1998). Triangulation in nursing research: Issues of conceptual clarity and purpose. *Journal of Advanced Nursing*, *28*(3), 631–641.

Shrimpton, R., Victora, C. G., de Onis, M., Lima, R. C., Blössner, M., & Clugston, G. (2001). Worldwide timing of growth faltering: Implications for nutritional interventions. *Pediatrics*, *107*(5), E75. https://doi.org/10.1542/peds.107.5.e75

Singh, A., Upadhyay, A. K., & Kumar, K. (2017). Birth Size, Stunting and Recovery from Stunting in Andhra Pradesh, India: Evidence from the Young Lives Study. *Maternal and Child Health Journal*, *21*(3), 492–508. https://doi.org/10.1007/s10995-016-2132-8

Smith, L. C., Ruel, M. T., & Ndiaye, A. (2005). Why Is Child Malnutrition Lower in Urban Than in Rural Areas? Evidence from 36 Developing Countries. *World Development*, *33*(8), 1285–1305. https://doi.org/10.1016/j.worlddev.2005.03.002

Society. (2012, November 12). *Earth's Freshwater*. National Geographic Society. http://www.nationalgeographic.org/media/earths-fresh-water/

Solar, O., & Irwin, A. (2010). A conceptual framework for action on the social determinants of health. Social determinnats of health. *Discussion Paper 2 (Policy and Practice)*, 41.

Srinivasan, C. S., Zanello, G., & Shankar, B. (2013). Rural-urban disparities in child nutrition in Bangladesh and Nepal. *BMC Public Health*, *13*, 581. https://doi.org/10.1186/1471-2458-13-581

Stamenkovic, Z., Djikanovic, B., Laaser, U., & Bjegovic-Mikanovic, V. (2016). The role of mother's education in the nutritional status of children in Serbia. *Public Health Nutrition*, *19*(15), 2734–2742. https://doi.org/10.1017/S1368980016000768

Stirratt, M. J., Meyer, I. H., Ouellette, S. C., & Gara, M. A. (2008). Measuring identity multiplicity and intersectionality: Hierarchical Classes Analysis (HICLAS) of sexual, racial, and gender identities. *Self and Identity*, *7*(1), 89–111. https://doi.org/10.1080/15298860701252203

Suttles, G. D. (1972). *The social construction of communities* (Vol. 111). University of Chicago Press Chicago.

Svalastog, A. L., Donev, D., Jahren Kristoffersen, N., & Gajović, S. (2017). Concepts and definitions of health and health-related values in the knowledge landscapes of the digital society. *Croatian Medical Journal*, *58*(6), 431–435. https://doi.org/10.3325/cmj.2017.58.431

Synnes, A. R., Ling, E. W., Whitfield, M. F., Mackinnon, M., Lopes, L., Wong, G., & Effer, S. B. (1994). Perinatal outcomes of a large cohort of extremely low gestational age infants (twenty-three to twenty-eight completed weeks of gestation). *The Journal of Pediatrics*, *125*(6 Pt 1), 952–960. https://doi.org/10.1016/s0022-3476(05)82015-3

Tabb, L. P., McClure, L. A., Quick, H., Purtle, J., & Diez Roux, A. V. (2018). Assessing the spatial heterogeneity in overall health across the United States using spatial regression methods: The contribution of health factors and county-level demographics. *Health & Place*, *51*, 68–77. https://doi.org/10.1016/j.healthplace.2018.02.012

Tam, C., & Freisthler, B. (2015). An exploratory analysis of linguistic acculturation, neighborhood, and risk behaviors among children of Southeast Asian immigrants. *Child and Adolescent Social Work Journal*, *32*(4), 383–393.

Taylor, D. L., Kahawita, T. M., Cairncross, S., & Ensink, J. H. J. (2015). The Impact of Water, Sanitation and Hygiene Interventions to Control Cholera: A Systematic Review. *PLOS ONE*, *10*(8), e0135676. https://doi.org/10.1371/journal.pone.0135676.

The DHS Program. (2013). *Demographic and Health Survey Methodology. DHSG4*.https://www.dhsprogram.com/pubs/pdf/DHSG4/Recode6_DHS_22March2013_DHSG4.pdf

Thomas, D. (1990). Intra-Household Resource Allocation: An Inferential Approach. *The Journal of Human Resources*, *25*(4), 635–664. JSTOR. https://doi.org/10.2307/145670

Thomas, D., Strauss, J., & Henriques, M.-H. (1991). How Does Mother's Education Affect Child Height? *The Journal of Human Resources*, *26*(2), 183. https://doi.org/10.2307/145920

Tigga, P. L., & Sen, J. (2016, November 3). *Maternal Body Mass Index Is Strongly Associated with Children -Scores for Height and BMI* [Research Article]. Journal of Anthropology; Hindawi. https://doi.org/10.1155/2016/6538235

Tobler, W. R. (1970). A Computer Movie Simulating Urban Growth in the Detroit Region. *Economic Geography*, *46*(sup1), 234–240. https://doi.org/10.2307/143141

Tong, X., & Bentler, P. M. (2013). Evaluation of a New Mean Scaled and Moment Adjusted Test Statistics for SEM. *Structural Equation Modeling : A Multidisciplinary Journal*, *20*(1), 148–156. https://doi.org/10.1080/10705511.2013.742403

Topa, G., & Zenou, Y. (2014). Neighbourhood versus Network Effects. In *Handbook of Regional and Urban Economics* (Vol. 5). http://real.wharton.upenn.edu/~duranton/Duranton_Papers/Handbook/Neighbourhood_versus_network_effects.pdf

Townsend, P., Davidson, N., & Whitehead, M. (1986). The Black report and the health divide. *Harmmondsworth: Penguin*.

Truth, S. (1851). *Ain't I a Woman?* Women's Rights Convention, Akron, Ohio.

Ukwuani, F. A., & Suchindran, C. M. (2003). Implications of women's work for child nutritional status in sub-Saharan Africa: A case study of Nigeria. *Social Science & Medicine (1982)*, *56*(10), 2109–2121. https://doi.org/10.1016/s0277-9536(02)00205-8

UNICEF. (2010). *Progress for Children: Achieving the MDGs with Equity*. UNICEF.

UNICEF. (2019). *The State of the World's Children 2019. Children, Food and Nutrition: Growing well in a changing world*.

UNICEF, WHO, & The World Bank. (2020). *Prevalence of stunting, height for age (% of children under 5) | Data | Joint child malnutrition estimates (JME)*. https://data.worldbank.org/indicator/SH.STA.STNT.ZS

United Nations Children's Fund, World Health Organisation, & World Bank. (2018). *Levels and Trends in Child Malnutrition* [Working Paper]. eSocialSciences.https://econpapers.repec.org/paper/esswpaper/id_3a12424.htm

Van de Poel, E., Hosseinpoor, A. R., Jehu-Appiah, C., Vega, J., & Speybroeck, N. (2007). Malnutrition and the disproportional burden on the poor: The case of Ghana. *International Journal for Equity in Health*, *6*, 21. https://doi.org/10.1186/1475-9276-6-21 van Lenthe, F. J., Brug, J., & Mackenbach, J. P. (2005). Neighbourhood inequalities in physical inactivity: The role of neighbourhood attractiveness, proximity to local facilities and safety in the Netherlands. *Social Science & Medicine*, *60*(4), 763–775. https://doi.org/10.1016/j.socscimed.2004.06.013

Victora, C. G., Adair, L., Fall, C., Hallal, P. C., Martorell, R., Richter, L., & Sachdev, H. S. (2008). Maternal and child undernutrition: Consequences for adult health and human capital. *The Lancet*, *371*(9609), 340–357. https://doi.org/10.1016/S0140-6736(07)61692-4

Vörösmarty, C. J., Green, P., Salisbury, J., & Lammers, R. B. (2000). Global Water Resources: Vulnerability from Climate Change and Population Growth. *Science*, *289*(5477), 284–288. https://doi.org/10.1126/science.289.5477.284

Walters, C. N., Rakotomanana, H., Komakech, J. J., & Stoecker, B. J. (2019). Maternal determinants of optimal breastfeeding and complementary feeding and their association with child undernutrition in Malawi (2015-2016). *BMC Public Health*, *19*(1), 1503. https://doi.org/10.1186/s12889-019-7877-8

Wamani, H., Åstrøm, A. N., Peterson, S., Tumwine, J. K., & Tylleskär, T. (2007). Boys are more stunted than girls in Sub-Saharan Africa: A meta-analysis of 16 demographic and health surveys. *BMC Pediatrics*, *7*(1), 17. https://doi.org/10.1186/1471-2431-7-17

Wamani, H., Tylleskär, T., Astrøm, A. N., Tumwine, J. K., & Peterson, S. (2004). Mothers’ education but not fathers’ education, household assets or land ownership is the best predictor of child health inequalities in rural Uganda. *International Journal for Equity in Health*, *3*(1), 9. https://doi.org/10.1186/1475-9276-3-9

Wambach, K. A., & Cole, C. (2000). Breastfeeding and adolescents. *Journal of Obstetric, Gynecologic, and Neonatal Nursing: JOGNN*, *29*(3), 282–294. https://doi.org/10.1111/j.1552-6909.2000.tb02050.x

Weber, L. (2017, August). *Two Boys With The Same Birth Story Will Live Vastly Different Lives*. HuffPost. https://www.huffpost. com/entry/ chronic-malnutrition-madagascarstunting_n_5772b07fe4b0f168323b 1eb0

Whincup, P. H., Cook, D. G., & Shaper, A. G. (1989). Early influences on blood pressure: A study of children aged 5-7 years. *BMJ (Clinical Research Ed.)*, *299*(6699), 587–591. https://doi.org/10.1136/bmj.29 9.6699.587

WHO. (n.d.). *Global database on National Nutrition Policies and Programmes*. Retrieved 23 June 2020, from https://extranet.who. int/nutrition/gina/en/node/8488

WHO. (2009). *Global Nutrition Policy Review 2009-2010*. https://extranet. who.int/nutrition/gina/en/node/8120

WHO. (2018a). *WHO | Ghana*. WHO; World Health Organization. http:// www.who.int/countries/gha/en/

WHO. (2018b). *WHO Ghana 2018 Annual Report*. WHO | Regional Office for Africa. https://www.afro.who.int/publications/who-ghana-2018-annual -report

WHO. (2019). *Children: Reducing mortality*. https://www.who.int/news-room/fact-sheets/detail/children-reducing-mortality

WHO | Breastfeeding. (n.d.). WHO; World Health Organization. Retrieved 14 May 2020, from https://www. who.int/ maternal_child_adolescent /topics/child/nutrition/breastfeeding/en/

WHO, C. on I. and A. for W. and C. H. (2013). *Keeping Promises, Measuring Results* (Final Report of the Commission).

WHO Child Growth Standards based on length/height, weight and age. (2007). *Acta Paediatrica*, *95*(S450), 76–85. https://doi.org/10.1111/ j.1651-2227.2006.tb02378.x

WHO Commission on Social Determinants of Health. (2008). *Closing the gap in a generation: Health equity through action on the social determinants of health: Commission on Social Determinants of Health final report*. World Health Organization.

WHO, UNICEF, & The World Bank. (2017). *WHO | UNICEF-WHO-The World Bank: Joint child malnutrition estimates - Levels and trends*. WHO; World Health Organization. Retrieved 5 March 2020, from http://www.who.int/nutgrowthdb/estimates/en/

WHO, W. H. O. (2015). *State of Inequality: Reproductive Maternal Newborn and Child Health: Interactive Visualization of Health Data*. World Health Organization.

WHO, W. H. O., & UNICEF, U. N. C. F. (2014). *Progress on sanitation and drinking water: 2014 update*. World Health Organization. https://apps.who.int/iris/handle/10665/112727

Williams, G. H. (2003). The determinants of health: Structure, context and agency. *Sociology of Health & Illness*, *25*(3), 131–154. https://doi. org/10.1111/1467-9566.00344

Wirth, M. E., Balk, D., Delamonica, E., Storeygard, A., Sacks, E., & Minujin, A. (2006). Setting the stage for equity-sensitive monitoring of the maternal and child health Millennium Development Goals. *Bulletin of the World Health Organization*, *84*(7), 519–527.

Wojcicki, J. M., & Heyman, M. B. (2010). Malnutrition and the Role of the Soft Drink Industry in Improving Child Health in Sub-Saharan Africa. *Pediatrics*, *126*(6), e1617–e1621. https://doi.org/10.1542/peds.2010-0461

World Health Organization. (2006). WHO child growth standards: Length/height for age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age, methods and development. *WHO Child Growth Standards: Length/Height for Age, Weight-for-Age, Weight-for-Length, Weight-for-Height and Body Mass Index-for-Age, Methods and Development.* https://www.cabdirect.org/cabdirect/abstract/20063123347

World Health Organization. (2010a). *A conceptual framework for action on the social determinants of health: Debates, policy & practice, case studies*.http://apps.who.int/iris/bitstream/10665/44489/1/9789241500852_eng.pdf

World Health Organization. (2010b). *Nutrition Landscape Information System (NLIS) country profile indicators: Interpretation guide*.

World Health Organization. (2013). *Handbook on health inequality monitoring: With a special focus on low-and middle-income countries*. World Health Organization.

World Health Organization (WHO) Constitution. (1948). https://www.who.int/about/who-we-are/constitution

Wu, J., Wang, J., Meng, B., Chen, G., Pang, L., Song, X., Zhang, K., Zhang, T., & Zheng, X. (2004). Exploratory spatial data analysis for the identification of risk factors to birth defects. *BMC Public Health*, *4*, 23. https://doi.org/10.1186/1471-2458-4-23

Yakubovich, A. R., Heron, J., & Humphreys, D. K. (2020). How do perceived and objective measures of neighbourhood disadvantage vary over time? Results from a prospective-longitudinal study in the UK with implications for longitudinal research on neighbourhood effects on health. *PLOS ONE*, *15*(4), e0231779. https://doi.org/10.1371/journal.pone.0231779

Yawson, A. E., Amoaful, E. O., Senaya, L. K., Yawson, A., Aboagye, P., Mahama, A. B., Selenje, L., & Ngongalah, V. (2017). The lancet series nutritional interventions in Ghana: A determinants analysis approach to inform nutrition strategic planning. *BMC Nutrition*, *3*. https://doi.org/10.1186/s40795-017-0147-1

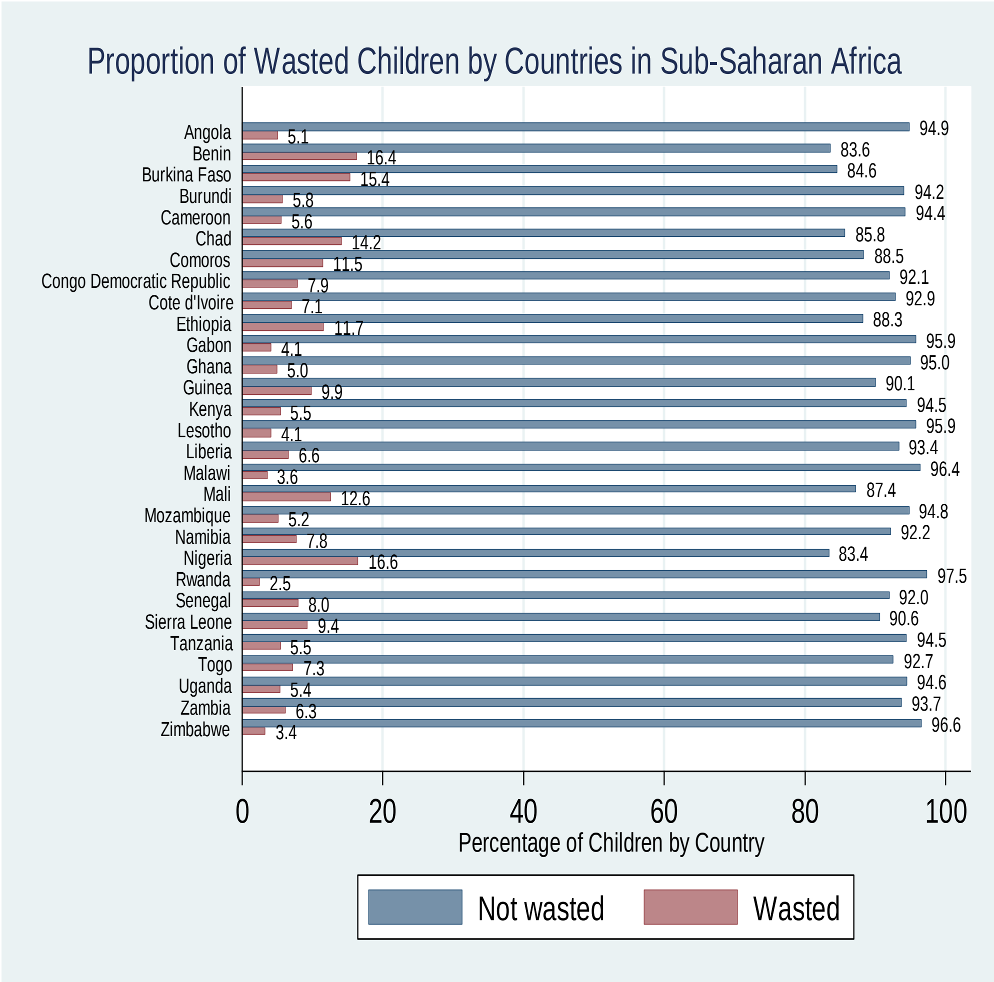
Yaya, S., Uthman, O. A., Okonofua, F., & Bishwajit, G. (2019). Decomposing the rural-urban gap in the factors of under-five mortality in sub-Saharan Africa? Evidence from 35 countries. *BMC Public Health*, *19*(1), 616. https://doi.org/10.1186/s12889-019-6940-9

You, Q., Chai, Y., & Jiang, C. (2018). Assessment of the spatial distribution of surface water resources in Changchun, China using remote sensing. *Journal of Water Supply: Research and Technology-Aqua*, *67*(5), 490–497. https://doi.org/10.2166/aqua.2018.155

Zere, E., & McIntyre, D. (2003). Inequities in under-five child malnutrition in South Africa. *International Journal for Equity in Health*, *2*(1), 7. https://doi.org/10.1186/1475-9276-2-7

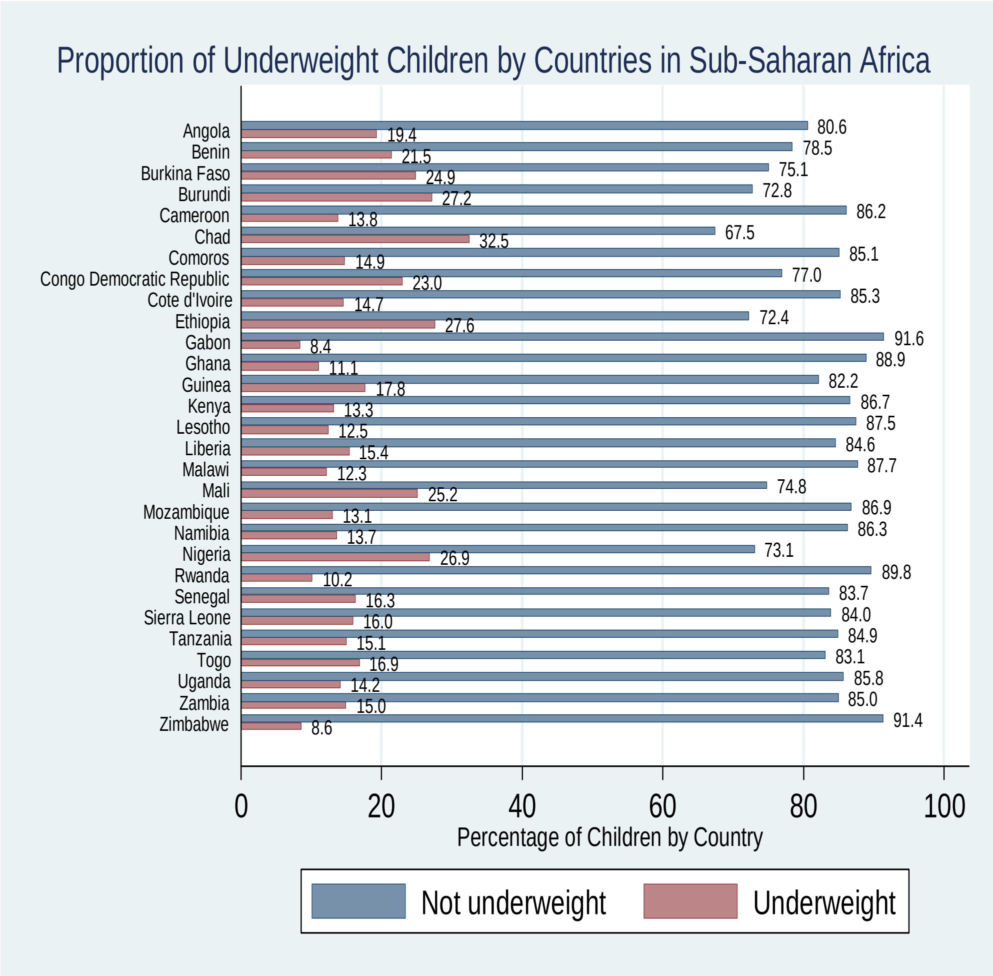
APPENDICES

APPENDIX A: DISTRIBUTION OF WASTED CHILDREN ACROSS SUB-SAHARAN AFRICAN COUNTRIES



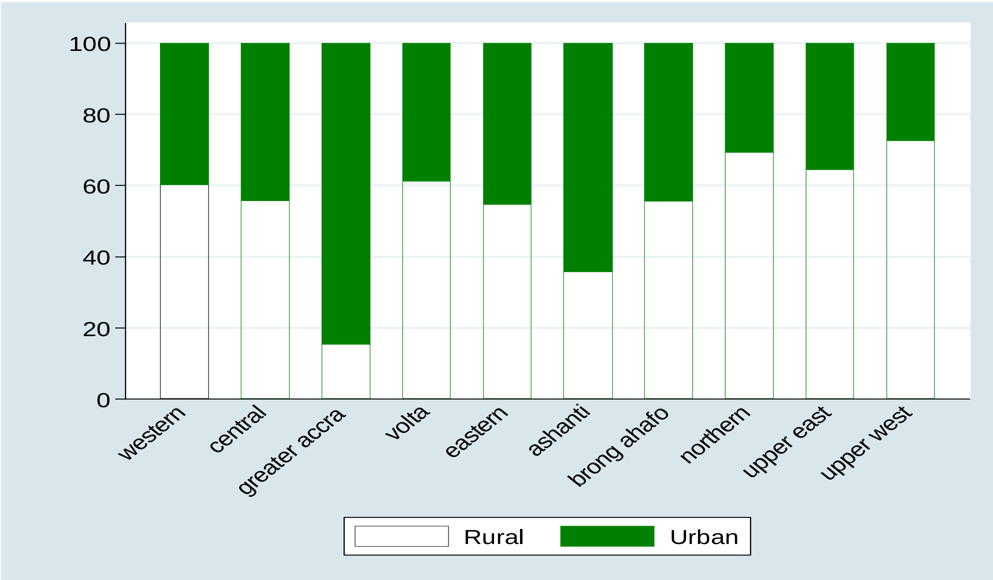
Source: Agyen (2020)

APPENDIX B: DISTRIBUTION OF UNDERWEIGHT CHILDREN ACROSS SUB-SAHARAN AFRICAN COUNTRIES



Source: Agyen (2020)

APPENDIX C: DISTRIBUTION OF CHILDREN UNDER-FIVE SAMPLED ACROSS REGIONS AND PLACE OF RESIDENCE



Source: Agyen (2020)

APPENDIX D: UNDER-FIVE MALNUTRITION PREVALENCE BY RURAL-URBAN RESIDENCE IN GHANA

Malnutrition indicator	Malnutrition Prevalence (%) by residence (rural –urban) for Ghana	
	Rural	Urban
Stunting	70.06 (n=365)	29.94 (n=156)
Wasting	67.42 (n=89)	32.58 (n=43)
Underweight	69.26 (n=205)	30.74 (n=91)

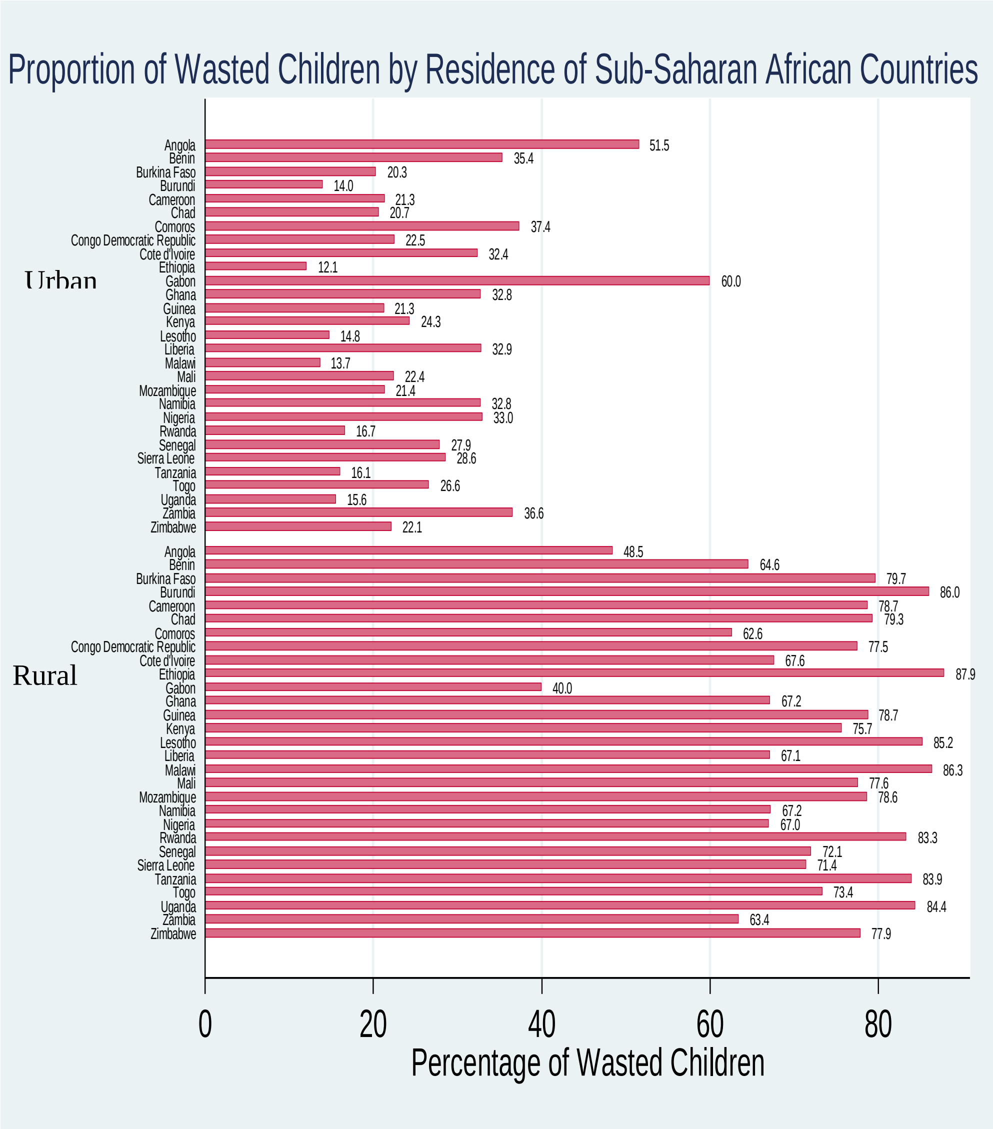
Source: Agyen (2020)

APPENDIX E: UNDER-FIVE MALNUTRITION PREVALENCE BY RURAL-URBAN RESIDENCE IN SUB-SAHARAN AFRICA

Malnutrition indicator	Malnutrition Prevalence (%) by residence (rural –urban) for sub-Saharan Africa	
	Rural	Urban
Stunting	78.28 (n=60,840)	72 (n=16,877)
Wasting	74 (n=13,785)	33 (n=4,801)
Underweight	79.18 (n=31,862)	32 (n=8,379)

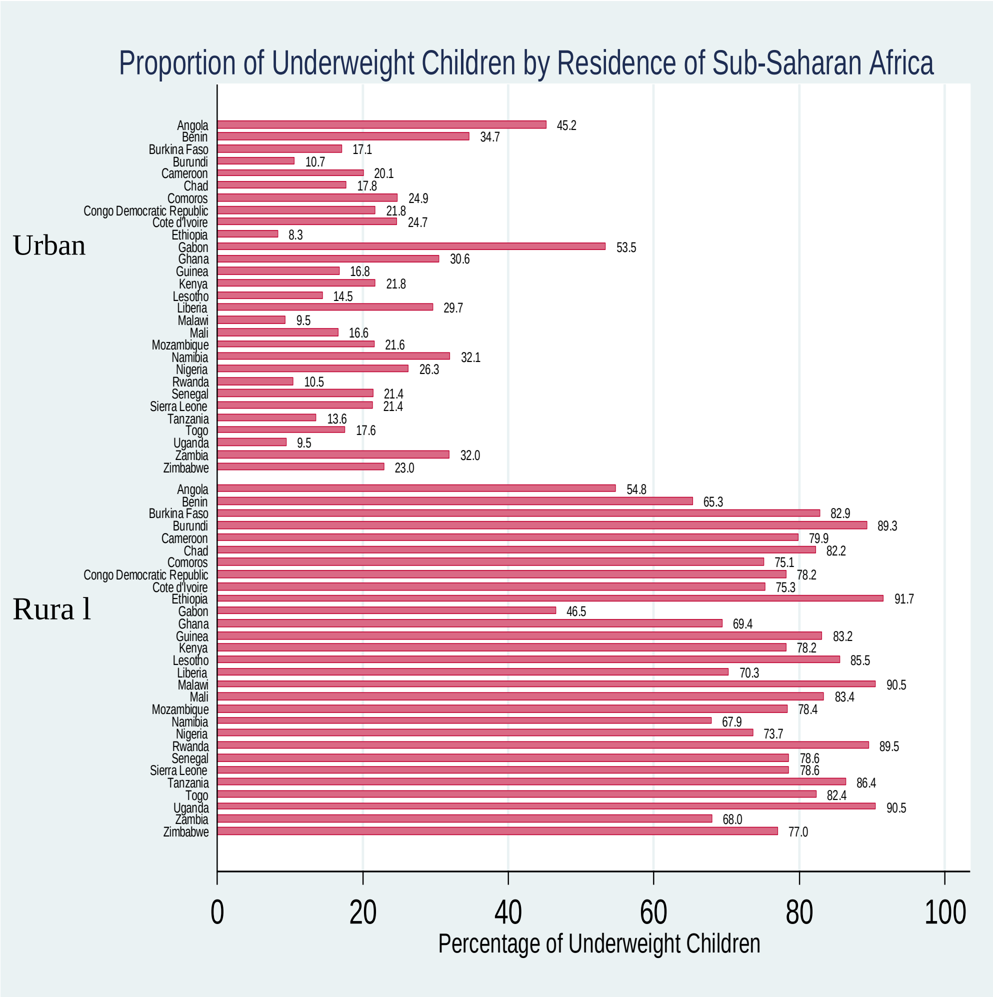
Source: Agyen (2020)

APPENDIX F: DISTRIBUTION OF WASTED CHILDREN ACROSS SUB-SAHARAN AFRICAN COUNTRIES' RESIDENCE



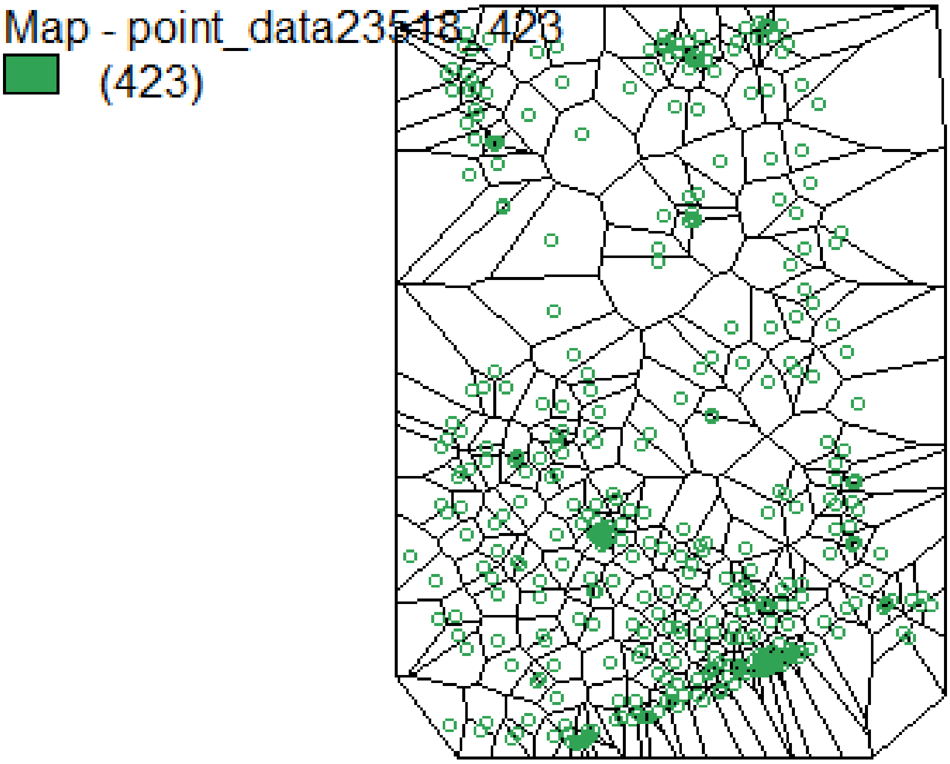
Source: Agyen (2020)

APPENDIX G: DISTRIBUTION OF UNDERWEIGHT CHILDREN ACROSS SUB-SAHARAN AFRICAN COUNTRIES' RESIDENCE



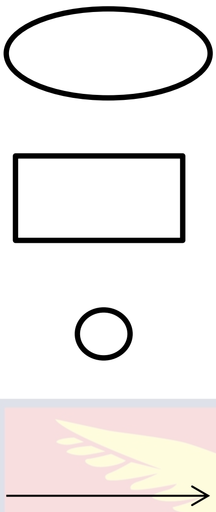
Source: Agyen (2020)

APPENDIX H: GHANA DHS SURVEY AREA SHOWING CLUSTER LOCATIONS AND THEISSEN POLYGONS



Source: Agyen (2020)

APPENDIX I: PATH DIAGRAM CONVENTIONS



Latent Variable

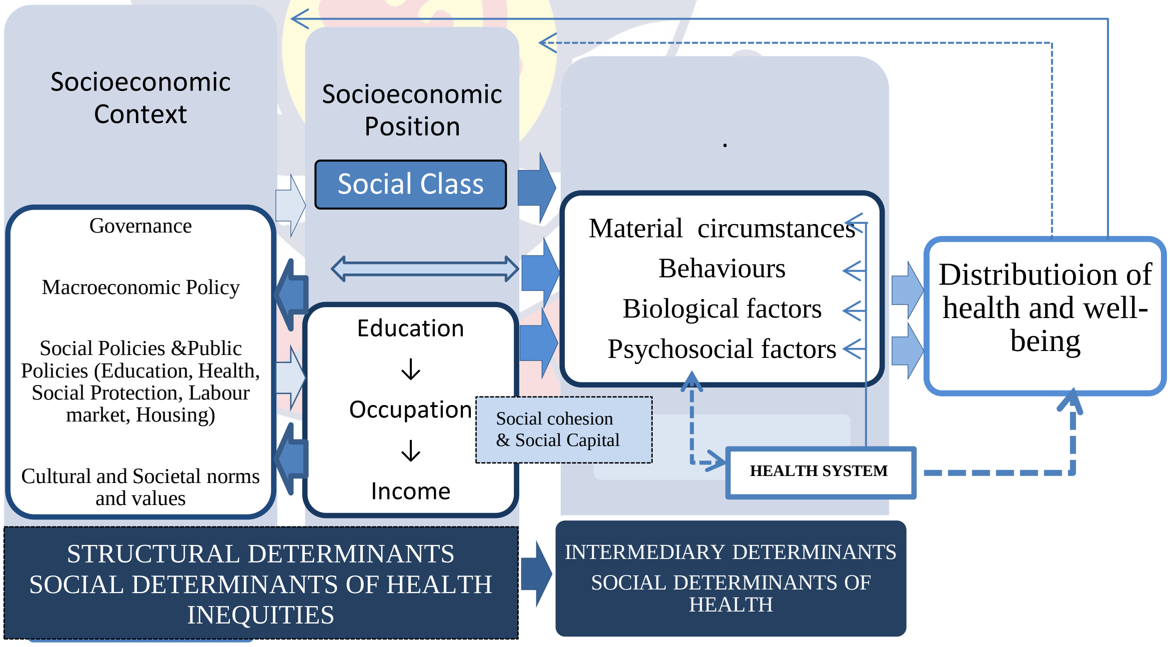
Observed Variable

Error Variance/disturbance term

Regression/directional path

Source: Agyen (2020)

APPENDIX J: CSDH CONCEPTUAL FRAMEWORK



The Commission for Social Determinants of Health Framework

Source: (CSDH, 2008; Solar & Irwin, 2010)

The framework describes the key areas underlying the drivers of health. More vividly, it provides a rationale for selecting social determinants for investigations in health and suggests how these may interact with one another. The rationale is to go beyond the contemporary attention on the immediate determinants of health to strengthen health equity worldwide. The framework shows how social structures and policies create social differences in sub-groups of the population. It groups the determinants of health into two; structural and intermediary. The structural determinants drive social stratification attribute individuals into socioeconomic positions based on policies and societal resources. The structural groupings are identified by social class, education, occupation, income and ethnicity. The magnitude of inequity in this regard are along the dimensions of a) biases, norms, and values 2) Global and national social and economic policies, and 3) processes of governance. The intermediary determinants on the other hand serve as pathway through which the structural determinants affect health. Depending on the type of policy or societal influence, different groups of people will have different material conditions, behaviour options and psychosocial support, which will translate to varying health conditions and statuses. More specifically, the material conditions include income, quality of physical environment and consumption potential. The behavioural and biological factors entail nutrition, social habits, physical activities and genetic factors. Finally, psychosocial support entails stressful living conditions, and access to social support. The social determinants of health outlined in the model are considered crucial in the underlying concept of the social concept explained by Marmot and McDowall (1986)

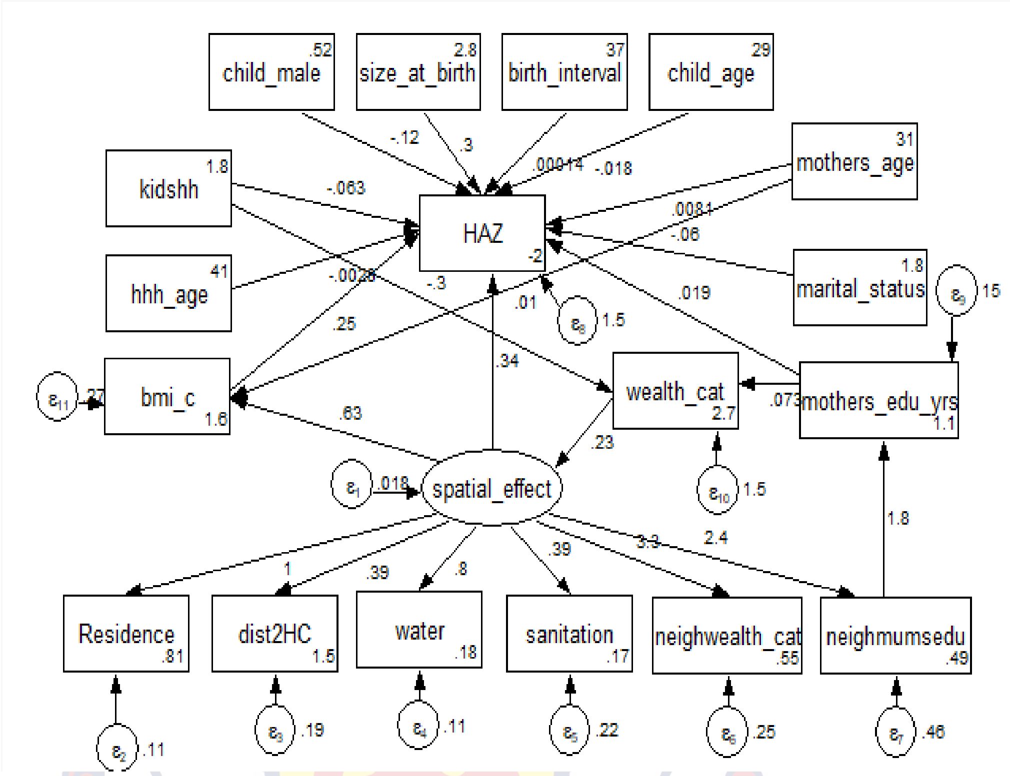
APPENDIX K: VARIABLE DESCRIPTION FOR STRUCTURAL EQUATION MODELS

Variable	Definition	Measurement	Abbreviation
Child age	Age of the child in categories	Measured as 0=<6; 1=6-8; 2=9-11; 3=12-17; 4=18-3; 5=24-35; 6=36-47; 7=48-59	Child_age
Child_male	Gender of child	1=male; 0=female	Child_male
Size at Birth	Size of the child on delivery	0=Very small; 1=small; 2=Average	Size_at_birth
Mother's Education	Mother's highest Educational attainment	0-15years	Mothers_edu_yrs
Mother's age	Age of the Mother of the child	Measured in years. Ranges from 15-45years	Mothers_age
Improved water source	Source of drinking water	0=not improved; 1=improved	water
Improved sanitation	Improved toilet facility	0=not improved; 1=improved	sanitation
Wealth	An index of the wealth status of	0=Poorest; 1=Poorer; 2=Middle; 3=Richer;	Wealth_cat

Variable	Definition	Measurement	Abbreviation
	the household	4=Richest	
Age of head of household	Age of the head of household	Measured in years. Ranges from 15years to 95years	Hhh_age
Residence	Residence status of the household	1=Rural 2=Urban;;	residence
Neighbour's wealth	Mean of the wealth status of the neighbouring households excluding the household of the observation itself	0=Poorest; 1=Poorer; 2=Middle; 3=Richer; 4=Richest	neighwealth_cat
Neighbour's mother's education	Mean of the years of schooling of neighbouring mothers excluding the mother of the observation itself		neighmumsedu
Distance to health center	Distance to health center in meters		Dist2HC

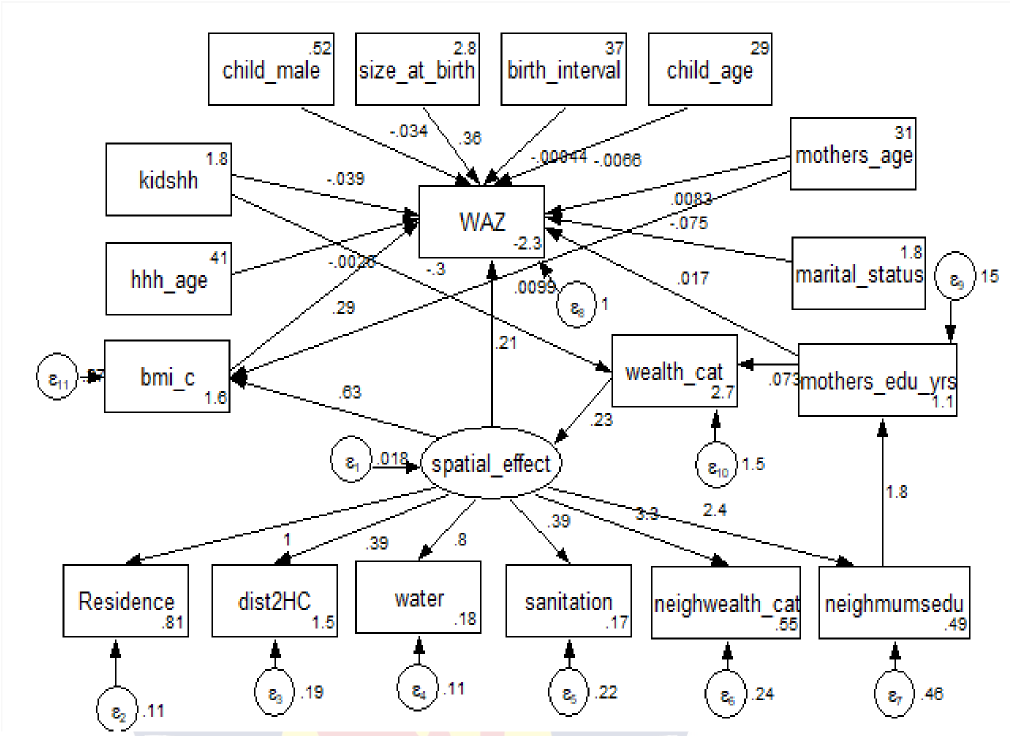
Source: Agyen (2020)

APPENDIX L: UNSTANDARDIZED ESTIMATES OF CHILD HEALTH OUTCOME (HAZ) FROM THE STRUCTURAL EQUATION MODEL



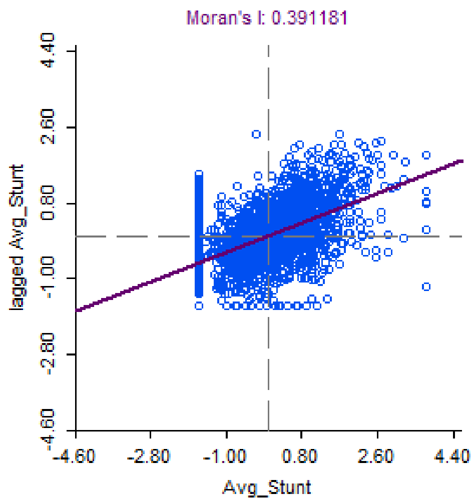
Source: Agyen (2020)

APPENDIX M: UNSTANDARDIZED ESTIMATES OF CHILD HEALTH OUTCOME (WAZ) FROM THE STRUCTURAL EQUATION MODEL



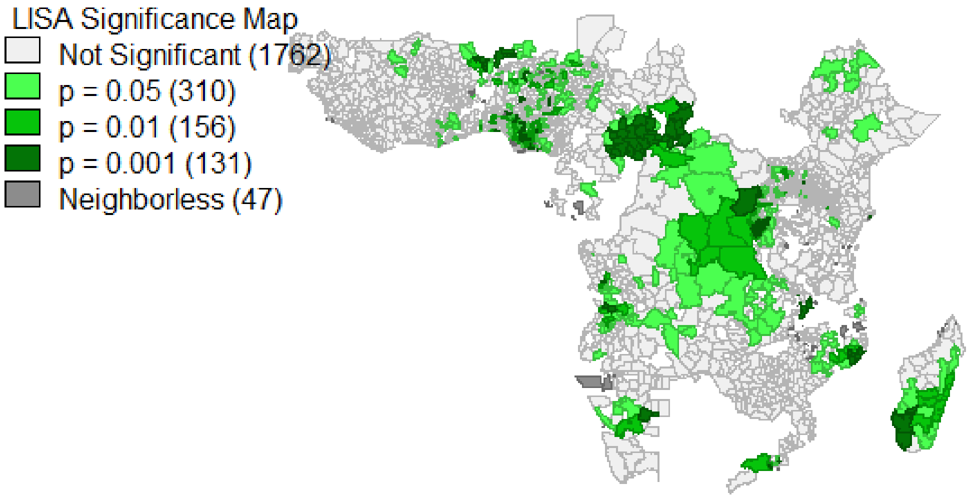
Source: Agyen (2020)

APPENDIX N: SCATTER PLOT FOR LISA MAP FOR SUB-SAHARAN AFRICA



Source: Agyen (2020)

APPENDIX O: SIGNIFICANCE MAP FOR LISA MAP FOR SUB-SAHARAN AFRICA



Source: Agyen (2020)

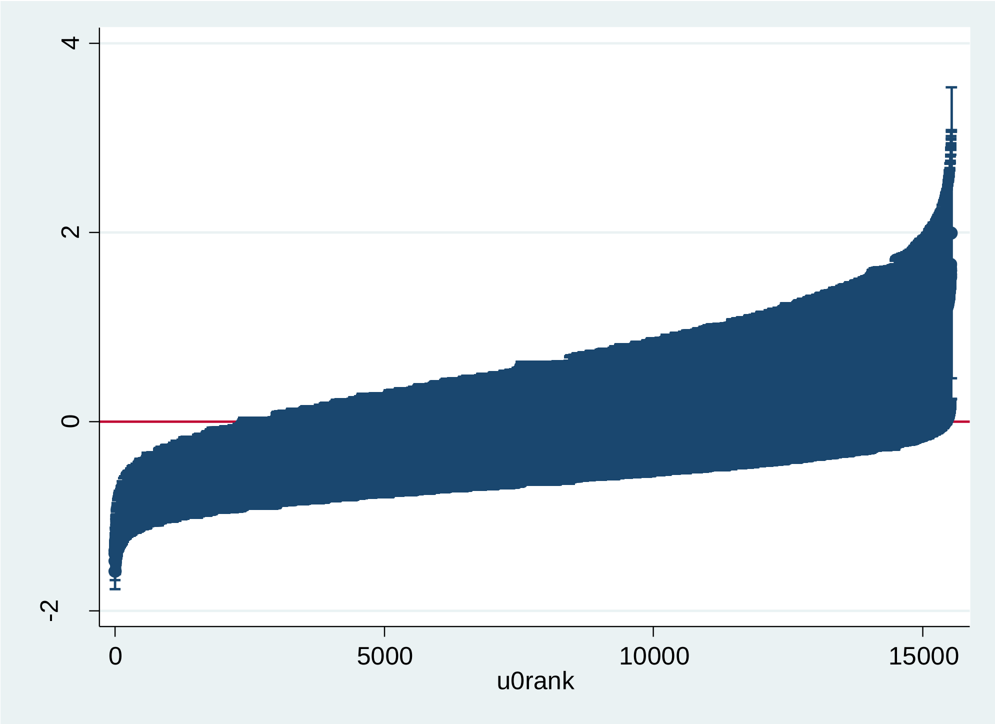
APPENDIX P: BASE MODEL SPECIFICATION

The empty/base/null model is the model with only the intercept and neighbourhood effects. This is specified as:

$$\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_0 + \mu_{0j}$$

where random effect μ_{0j} is specific to the neighbourhood j and the intercept β_0 is apportioned to all the neighbourhood. μ_{0j} is assumed to follow a normal distribution with variance σ_{u0}^2.

APPENDIX Q: CATERPILLAR PLOT OF ESTIMATED RESIDUALS FOR ALL THE NEIGHBOURHOOD EFFECTS



Source: Agyen (2020)

APPENDIX R: ESTIMATED ODDS RATIOS AND THEIR ASSOCIATED STANDARD ERRORS OF THE EFFECT OF MOTHERS' EDUCATION (SECONDARY AND HIGHER) ON STUNTING

	Logistic (1)		Multilevel without contextual effect (2)		Multilevel with contextual effect of mothers' secondary education (3)		Multilevel with contextual effect of mothers' higher education (4)	
Fixed Effects: Individual-level	**Odds Ratio**	**Std. Error**	**Odds Ratio**	**Std. Error**	**Odds Ratio**	**Std. Error**	**Odds Ratio**	**Std. Error**
Child age (Base= Below 6)								
6-8	1.240***	0.039	1.244***	0.041	1.245***	0.041	1.245***	0.041
9-11	1.888***	0.057	1.939***	0.061	1.943***	0.061	1.940***	0.061
12-17	3.062***	0.075	3.244***	0.083	3.247***	0.083	3.243***	0.083
18-23	5.138***	0.128	5.706***	0.148	5.717***	0.148	5.706***	0.148
24-35	5.357***	0.121	5.959***	0.140	5.971***	0.140	5.961***	0.140
36-47	4.517***	0.102	4.926***	0.116	4.929***	0.116	4.926***	0.116
48-59	3.489***	0.080	3.734***	0.089	3.738***	0.089	3.734***	0.089
Sex of Child (Base = Male)								
female	0.781***	0.008	0.766***	0.008	0.767***	0.008	0.766***	0.008
Size at birth (Base=very small)								
Small	0.978	0.024	0.906***	0.023	0.913***	0.024	0.906***	0.023
Average or Larger	0.683***	0.014	0.613***	0.013	0.618***	0.013	0.613***	0.013
Mother's education (Base=No Education)								
Primary	0.821***	0.009	0.844***	0.011	0.886***	0.012	0.849***	0.011
Secondary	0.598***	0.009	0.635***	0.011	0.742***	0.015	0.648***	0.011
Higher	0.318***	0.014	0.342***	0.016	0.410***	0.020	0.418***	0.021
mothers_age	0.990***	0.001	0.989***	0.001	0.990***	0.001	0.990***	0.001
Improved water source	0.890***	0.009	0.911***	0.012	0.924***	0.012	0.915***	0.012
Improved Sanitation	0.883***	0.010	0.852***	0.012	0.866***	0.012	0.856***	0.012

Wealth (Base=Poorest)								
Poorer	0.947***	0.013	0.919***	0.014	0.921***	0.014	0.918***	0.014
Middle	0.882***	0.013	0.856***	0.014	0.859***	0.014	0.856***	0.014
Richer	0.794***	0.013	0.762***	0.014	0.766***	0.015	0.764***	0.014
Richest	0.592***	0.013	0.572***	0.014	0.576***	0.014	0.585***	0.014
Age of head of household	0.998***	0.000	0.999+	0.000	0.999	0.000	0.999+	0.000
Ever breastfed(base=Yes)								
No	1.035	0.034	1.062+	0.037	1.061+	0.037	1.062+	0.037
Intercept	0.453***	0.018	0.405***	0.018	0.441***	0.019	0.414***	0.018
Contextual Effect: Neighbourhood-level variables								
Residence(Base=Urban)								
Rural	1.127***	0.015	1.176***	0.021	1.089***	0.020	1.144***	0.021
Altitude	1.0002***	0.000	1.0002***	0.000	1.0002***	0.000	1.0002***	0.000
Proportion of mothers with Sec/higher levels of education					0.555***	0.019	0.274***	0.030
Between neighbourhood variance	-		0.323***	0.009	0.317***	0.009	0.320***	0.009
Intra-class Correlation	-		0.089***	0.002	0.088***	0.002	0.089***	0.002
Groups	-		15,470		15,470		15,470	
Observations	204,447		204,447		204,447		204,447	
Log-Likelihood	-123079.34		-121162.2		-121011.09		-121090.4	

Source: Agyen (2020)

APPENDIX S: EFFECT OF MOTHERS EDUCATION DEPENDENT ON RESIDENCE

Fixed Effects: Individual-level	Coefficient	Std. Error	Odds Ratio	Std. Error
Child age (Base= Below 6)				
6-8	0.219***	0.033	1.245***	0.041
9-11	0.665***	0.031	1.944***	0.061
12-17	1.178***	0.026	3.248***	0.083
18-23	1.744***	0.026	5.718***	0.148
24-35	1.787***	0.023	5.970***	0.140
36-47	1.595***	0.024	4.930***	0.116
48-59	1.319***	0.024	3.738***	0.089
Sex of child (Base = Male)				
female	-0.265***	0.010	0.767***	0.008
Size at birth (Base=very small)				
Small	-0.091***	0.026	0.913***	0.024
Average or Larger	-0.481***	0.022	0.618***	0.013
Mother's education (Base=No Education)				
Primary	-0.116***	0.014	0.890***	0.012
Secondary	-0.295***	0.020	0.744***	0.015
Higher	-0.899***	0.049	0.407***	0.020
mothers_age	-0.010***	0.001	0.990***	0.001
Improved water source	-0.078***	0.013	0.925***	0.012
Improved Sanitation	-0.144***	0.014	0.866***	0.012
Wealth (Base=Poorest)				
Poorer	-0.081***	0.015	0.922***	0.014
Middle	-0.149***	0.017	0.861***	0.014
Richer	-0.266***	0.019	0.766***	0.015
Richest	-0.554***	0.025	0.574***	0.014
Age of head of household	-0.001	0.000	0.999	0.000
Ever breastfed(base=Yes)				
No	0.059^{+}	0.035	1.061^{+}	0.037
Intercept	-0.871***	0.045	0.414***	0.018
Contextual Effect: Neighbourhood-level variables				
Residence(Base=Urban)				
Rural	0.147***	0.018	1.158***	0.028
Altitude	0.0002***	0.000	1.0002***	0.000
Proportion of mothers with Sec/higher levels of education	-0.471***	0.034	0.624***	0.029
Proportion of mothers with Sec × residence	-0.209***	0.055	0.812***	0.045
Between neighbourhood variance	0.315***	0.009	0.315***	0.009
Intra-class Correlation	0.088***	0.002	0.088***	0.002
Groups	15,470		15,470	
Observations	204,447		204,447	
Log-Likelihood	-121003.94		-121003.94	

*p<0.05; **p<0.01; ***p<0.001*

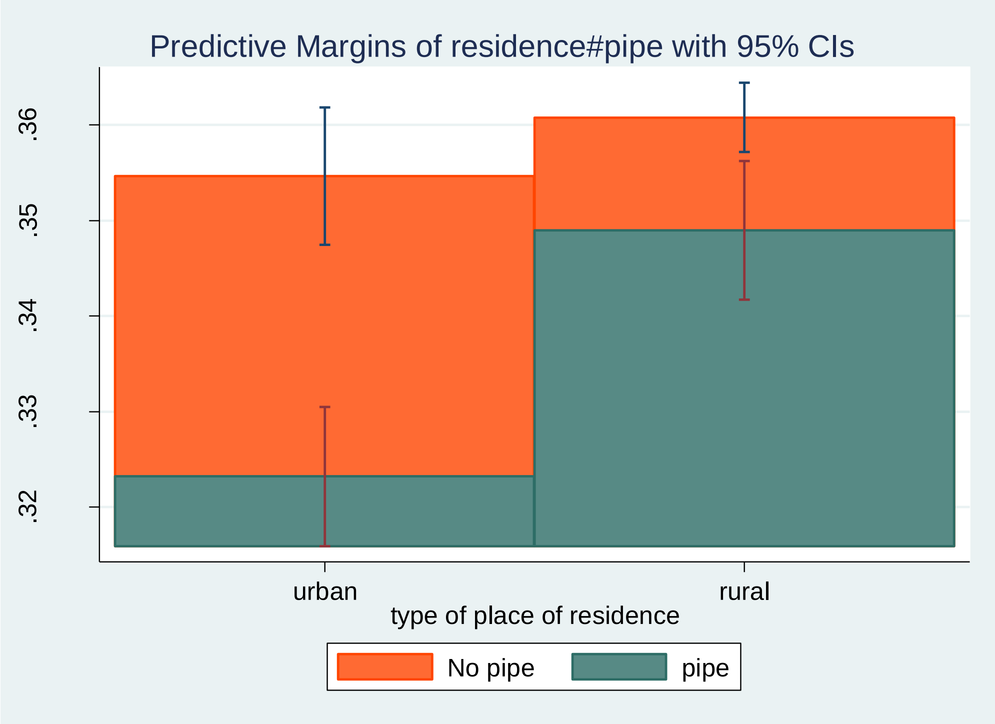
Source: Agyen (2020)

APPENDIX T: ESTIMATES OF THE PREDICTIVE MARGINS OF THE EFFECT OF PIPED WATER ON STUNTING DEPENDING ON RESIDENCE AND HOLDING ALL OTHER VARIABLES AT THEIR MEANS

Residence#Pipe	Margin	Std. Error	Z	P-Value
urban#no pipe	0.354649	0.003679	96.41	0.000
urban#pipe	0.323229	0.003714	87.02	0.000
rural#no pipe	0.360783	0.001851	194.91	0.000
rural#pipe	0.348963	0.003707	94.14	0.000

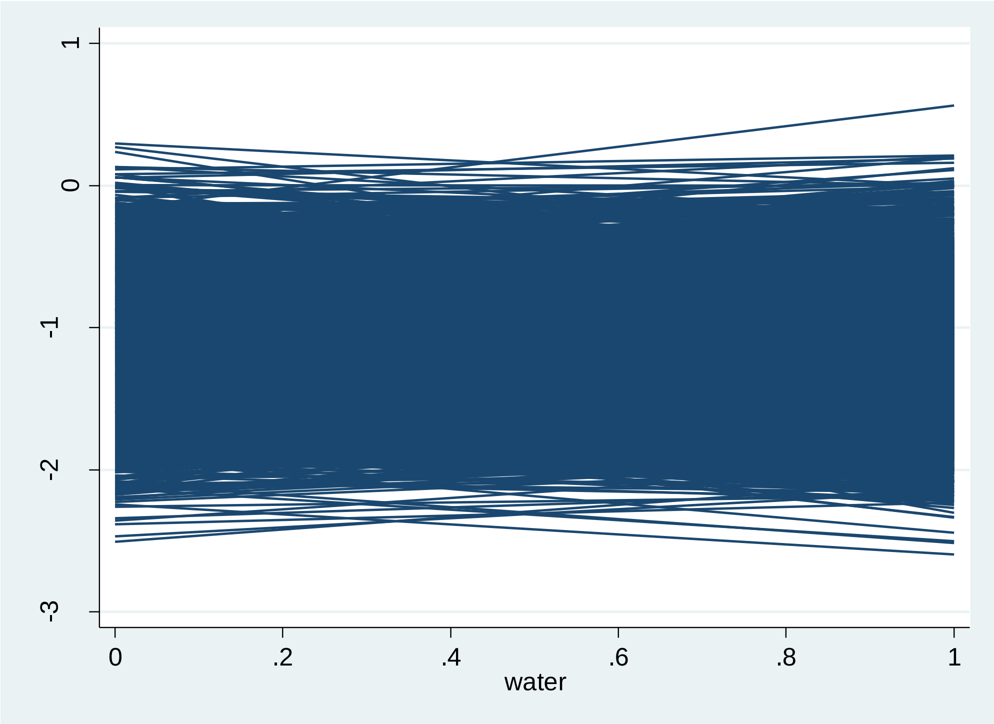
Source: Agyen (2020)

Appendix U: Plot of the Predictive Margins of the effect of piped water on stunting depending on residence



Source: Agyen (2020)

APPENDIX V: PLOT OF THE 15470 NEIGHBOURHOOD REGRESSION SLOPES FOR IMPROVED WATER



Source: Agyen (2020)