ADDIS ABABA UNIVERSITY

COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR POPULATION STUDIES

Inequalities in Child Survival in Ethiopia: A two-decade experience

By: Negussie Shiferaw

A PhD Thesis Submitted to Center for Population Studies, College of Development Studies, Addis Ababa University for the Fulfillment of the Requirements for the Degree of Doctor of Philosophy (PhD) in Population Studies.

Supervisor: Prof. Nigatu Regassa

April, 2024
Addis Ababa, Ethiopia

Dissertation Approval

Addis Ababa University

School of Graduate Studies

This is to certify that the thesis prepared by Negussie Shiferaw entitled: ***"Inequalities in Child Survival in Ethiopia: A Two Decade Experience"*** and submitted in fulfillment of the requirements for the Degree of Doctor of Philosophy (in Population Studies) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Signed by the Examining Committee:

Eshetu Gurmu		23-02-2024
Chairman, Examining Committee	Signature	Date
Leo van Wissen		23-02-2024
External Examiner	Signature	Date
Wubegzier Mekonnen (PhD)		23-02-2024
Internal Examiner	Signature	Date
Nigatu Regassa		09/04/2024
Advisor	Signature	Date
Chalachew Getahun		11/04/2024
Chair of Department or Graduate Program Coordinator	Signature	Date

Author's Statement

I, Negussie Shiferaw Tessema, declare that this Thesis entitled "**Inequalities in Child Survival in Ethiopia: A two-decade experience**" and the work presented in it are my own work. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- No part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution.
- Where I have quoted from the work of others, the source is always given.
- Accordingly, all the resources used or quoted have been indicated and acknowledged in the reference. With such acknowledgement, this thesis is entirely my own work.

Negussie Shiferaw **Signature**______ **April, 2024**

Table of Contents

List of Figures

List of Tables

Acknowledgement

First of all, I would like to thank Almighty God, who provided the strength and peaceful spirit to accomplish this thesis work.

I have no words to express my heartfelt thanks and sincere appreciation to my supervisor Prof. Nigatu Regassa for his unreserved guidance, constructive comments, and unlimited support starting from the conception of this research. All the successes in my PhD work are due to his professional advice, actionable encouragement, and supportive supervision along with the provision of speedy feedback. May God Bless him and his family as well.

My acknowledgement also goes to the Center for Population Studies of Addis Ababa University for facilitating instructors, seminars, PhD thesis proposal assessors, and PhD thesis examiners. I would like to extend my thanks to Prof. Terefe Degefa and Dr. Hirut Terefe who assessed my PhD thesis proposal and provided constructive comments in shaping this research. I would like to acknowledge my PhD instructors and classmates for the supportive teaching-learning process and teamwork. I also thank Prof. Abiy Yigzaw for his kind support in copy editing.

I would also like to thank the United Nations Children's Fund (UNICEF) Ethiopia, immunization team, and my deepest thanks go to my immediate supervisor, Mr. Amsalu Shiferaw for his kind understanding of my research work and for minimizing workload during the study period. I would also like to thank the Demographic and Health Survey (DHS) Program, IFC and Central Statistics Agency (CSA)[Ethiopia] for providing online permission to use Data for Analysis.

Finally, I am sincerely grateful to my family members for their unlimited and unconditional backing from the beginning to the end of the thesis, and completion of my study would not be possible without their understanding and caring support.

Abbreviations and Acronyms

AIC	Akaike's Information Criterion
AGP	Agriculture Growth Program
BIC	Bayesian Information Criterion
CIAF	Composite Index of Anthropometric Failure
CSA	Central Statistical Agency
DHS	Demographic and Health Survey
EAs	Enumeration Areas
EBI	Ethiopian Biodiversity Institute
EDHS	Ethiopia Demographic and Health Survey
EMDHS	Ethiopia Mini Demographic and Health Survey
EPHC	Ethiopia Population and Housing Census
EPHI	Ethiopian Public Health Institute
FAO	Food and Agriculture Organization
FDRE	Federal Democratic republic of Ethiopia
GDP	Gross Domestic Product
GHI	Global Hunger Index
GOE	Government of Ethiopia
HDI	Human Development Index
HEAT	Health Equity Assessment Toolkit
HEP	Health Extension Program
ICC	Inter-class Correlation
ICF	Intermediate Care Facility
IFAD	International Fund for Agricultural Development
LMICs	Low and Middle- Income Countries
MDG	Millennium Development Goal
MICS	Multiple Indicator Cluster surveys
MOA	Ministry of Agriculture
MOR	Median Odds Ratio
LR	Likelihood Ratio
ORS	Oral Rehydration Solutions
PAF	Population Attributable Fraction
PPP	Purchasing Power Parity
PRIME	Pastoralist Areas Resilience Improvement and Market Expansion
PSNP	Productive Safety Net Program
SDG	Sustainable Development Goal
SE	Standard error
SUN	Scaling Up Nutrition
SSA	Sub-Saharan Africa
U5M	Under-five Mortality
U5MR	Under-five Mortality Rate
UN	United Nations
UNDP	United Nations Development Program
UNICEF	United Nations Children's Fund
UN IGME	United Nations Inter-agency Group for Child Mortality Estimation
USAID	United Sates Agency for International Development
VIF	Variance Inflation Factor
WHO	World Health Organization

Abstract

Introduction: *Globally, 269 million children aged 6-59 months were anemic globally in 2019; 149.2 million under-five children were affected by undernutrition in 2020; and five million children also died before reaching the age of five years in 2021 alone. Children residing in Sub-Saharan African countries had 15- and 19-times higher risk of mortality than children in Europe and Northern America, and the region of Australia and New Zealand, respectively. Ethiopia, one of the Sub-Saharan African countries, is home to a high burden of under-five mortality and is ranked third in Africa and tenth in the world. The objective of this thesis was to examine trends and key predictors of inequalities in under-five mortality, undernutrition, and anemia in Ethiopia for the period 2000 to 2019) including population-level impacts of risk factors and spatial patterns.*

Methods*: The repeated cross-sectional study design was based on a total pooled sample of 48,782 under-five children drawn from five rounds of the Ethiopian Demographic and Health Surveys (2000-2019). The present thesis employed dominance analysis to identify the most dominant drivers of childhood undernutrition, anemia, and under-five mortality. Multilevel binary logistic regression was used to estimate the effect of the determinants of childhood undernutrition, anemia, and under-five mortality among under-five children at individual, household, and community levels. Blinder-Oaxaca decomposition techniques, concentration index, Theil and multivariate decomposition and decomposition rate analyses techniques were used to examine inequality in childhood anemia, undernutrition, and under-five mortality. Population Attributable Fractions (PAFs) were used to estimate the proportion of under-five children that could be prevented from childhood undernutrition, anemia, and under-five mortality by removing inequalities. From spatial analysis, Moran's I and Getis-Ord Gi* statistics were employed to examine spatial patterns and clustering of childhood undernutrition, childhood anemia, and under-five mortality in the country.*

Results*: Maternal education, place of residence, and household wealth status accounted for 83.48% of the predicted variances for childhood undernutrition. The regional category was found to be the dominant driver of inequalities in childhood anemia, accounting for 50.56% of the predicted variance. Maternal education, child sex, and place of residence were found to be the most dominant drivers of inequality in under-five mortality, accounting for 89.3% of the predicted variance. Absolute socioeconomic inequality in childhood undernutrition prevalence was declined by 9.72 during the study period (2000 to 2019). The total relative inequality in childhood anemia declined from 0.620 in 2005 to 0.548 in 2016. The present thesis also showed that there would be 47 deaths per 1000 children for urban poor and 21 deaths per 1000 children for urban non-poor, resulting in 26 deaths per 1000 children change in urban poor when applying the urban non-poor coefficient and characteristics to urban poor behavior. About 72% of the reported under-five mortality could possibly be averted by removing the use of unimproved toilet facilities, early age childbirth (<18 years old mothers), and a large number of children ever born to mothers and less than six months breastfeeding practice at population-level. Childhood undernutrition, childhood anemia, and under-five mortality had statistically significant positive spatial autocorrelation, and clustered patterns with the Z-score value of 18.52, 22.45, and 6.56, respectively, in 2016.*

Conclusion*: Childhood anemia, undernutrition, and under-five mortality were unequally among under-five children in Ethiopia, and largely concentrated among low socioeconomic status population groups. The thesis strongly suggests the implementation of multidimensional, multisectoral, and geographic-specific interventions to significantly reduce the inequalities in child survival.*

Key works*: Drivers, inequalities, childhood anemia, undernutrition, under-five mortality, Ethiopia.*

CHAPTER ONE
INTRODUCTION

1.1. Background

Inequality in child survival refers to the existence of disparity on likelihood of reaching the age of five due to variations in socioeconomic status, geographical location, or other demographic factors (Mberu et al.; 2023). Evidence revealed that significant inequalities persist among different socioeconomic, regional, and ethnic groups, necessitating targeted interventions (Victora et al., 2016). For instance, children from low-income families or impoverished areas exhibit a greater susceptibility to mortality compared to their affluent counterparts (World Bank, 2022a). This inequality is particularly pronounced in regions like sub-Saharan Africa, where child mortality rates remain disproportionately high (Mberu et al., 2023). While progress has been made globally, the pace of improvement has slowed in recent years, with sub-Saharan Africa bearing the brunt of these challenges (World Bank, 2022a). In Ethiopia, despite overall progress in reducing under-five mortality, internal disparities persist, with administrative regions, rural areas, children born into impoverished households, and those with less educated mothers facing heightened mortality risks, particularly male newborns (Shibre et al., 2020).

Child survival was one of the core components of the Millennium Development Goals (MDGs) (Mckinnon et al., 2014). The Sustainable Development Goals (SDGs) are adopted to succeed the MDGs, particularly, SDG-3 explicitly relates to health—to “ensure healthy lives and promote well-being for all ages." This goal is translated into 13 targets including two targets related to the reduction of neonatal and under-five mortality (UN, 2016). The SDG for child health specifically targets improving child survival and reducing inequality within and among countries by 2030 (

UN, 2016). According to the works of Mosley and Cohen, child survival refers to both childhood morbidity and mortality (Mosley & Chen, 1984). Undernutrition and anemia are the two key childhood morbidities in Sub-Saharan Africa (Nkosi-Gondwe et al., 2021). Under-five mortality, undernutrition, and anemia are the most commonly used child survival indicators in works of literature (Mosley & Chen, 1984; Nkosi-Gondwe et al., 2021).

Remarkable progress had been made in child survival in the world during the past decades. For instance, one in twenty-six children died before reaching age five in 2021 compared to one in eleven in 1990 (UN IGME, 2022). The global under-five mortality rate declined by 59 percent from 93 deaths per 1,000 live births in 1990 to 38 in 2021 (Sharrow et al., 2022; UN IGME, 2022). Accordingly, the annual rate of reduction in the global under-five mortality rate increased from 1.8 percent in 1990-1999 to 2.4 percent in 2000-2021 (UN IGME, 2022).

Despite considerable reductions in under-five mortality over the past two decades, the number of under-five children deaths remains large and improving child survival ruins a matter of urgent concern at the global level (Sharrow et al., 2022). According to UN IGME, roughly 13,800 under-five deaths occurred every day in 2021 globally, and the Sub-Saharan Africa (SSA) region had 19 times higher U5MR than the region of Australia and New Zealand in 2021(UN IGME, 2022). Ethiopia is among the countries with a high burden of the under-five mortality with a U5MR of 59 deaths per 1000 live births (Ethiopian Public Health Institute (EPHI) & ICF, 2021).

Moreover, undernutrition is a key child survival indicator and remains a critical health concern in developing countries. According to UNICEF, WHO, and World Bank joint estimate,149.2 million under-five children suffered from stunting and 45.4 million were affected by wasting, of which

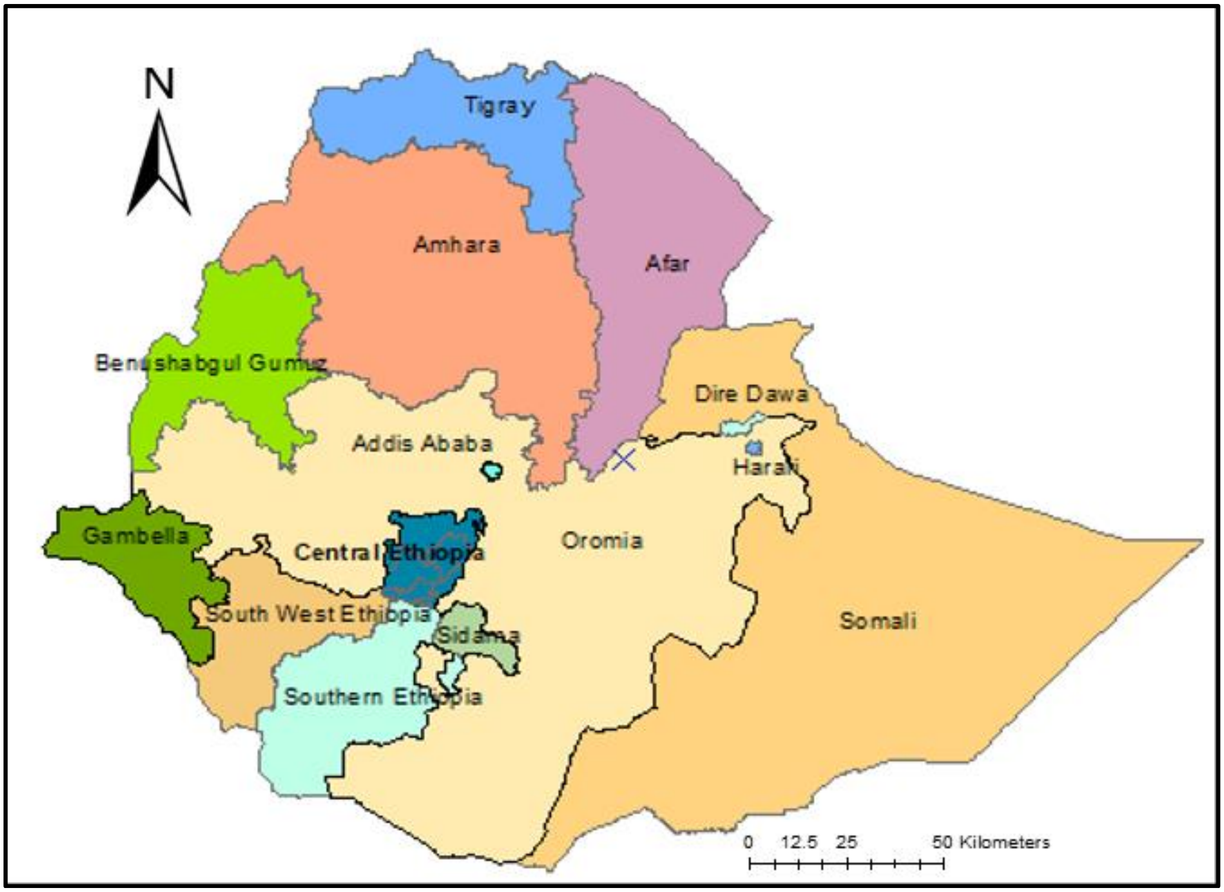
13.6 million were severely wasted globally in 2020 (UNICEF et al., 2020). Africa and Asia remain with high number of under-five children with stunting. In Africa, the number of stunted under-five children has increased from 54.4 to 61.4 million during the period 2000-2020 (UNICEF et al., 2020). In Ethiopia, the 2019 data showed that 37%, 21% and 7% of under-five children were stunted, underweighted, and wasted, respectively (Ethiopian Public Health Institute (EPHI) & ICF, 2021).

Furthermore, anemia is another child survival indicator, affecting the lives of more than two billion people globally, accounting for 30% of the world's population. It is one of the most common public health problems in developing countries (Tesfaye et al., 2020). Globally, 40% of children were anemic in 2019 and SSA is one of the regions with the highest burden of Anemia (Safiri et al., 2021). The prevalence of anemia among children aged 6-59 months in SSA was 64.1% based on the pooled data from 32 countries from 2008-2016 (Tesema, et al., 2021). In Ethiopia, more than half (57%) of children 6 to 59 months suffer from some degree of anemia, of which 25% were mildly anemic, 29% were moderately anemic, and 3% were severely anemic (Central Statistical Agency (CSA) and ICF, 2016).

Currently, the United Nations (UN) urges countries to improve child survival by ending preventable deaths of under-five children, eliminating malnutrition, ensuring access to preventive vaccines, and reducing inequalities within and among countries by 2030 (UN, 2016). To achieve SDGs, it is essential to monitor equity while implementing child survival interventions. In this regard, developing countries like Ethiopia should pay due attention to assessing inequalities in child survival based on key drivers of inequality in to achieve the SDGs (Yourkavitch et al., 2018). However, no single indicator can tell the inequalities in child survival. Given the prevailing high level of inequalities in the key indicators (i.e., childhood mortality, undernutrition, and anemia), it is important to assess inequality in child survival in Ethiopia based on key drivers of inequality.

1.2. Country Context

Ethiopia is ethnically and culturally diverse, and the second most populous country in Africa (UNICEF, 2019b; USAID, 2021b), and one of the poorest countries in the world (World Bank, 2020a). The country has extensive altitudinal and geographic variations, ranging from 116 meters below sea level to a peak of 4620 meters above sea level (EBI, 2014). As of August 2023, Ethiopia administratively consisted of 12 regional states (including three newly established regions from the old SNNPR: Sidama, South West, and Central Ethiopia) and two city administrations (Figure 1-1).



Source: Author's construction

Figure 1-1:Map of regions of Ethiopia

While Ethiopia's poverty rate based on income has shown a decline since 2000, the country still faces a significant challenge with multidimensional poverty. In 2000, Ethiopia was the third-poorest country in the world, with 55.3 percent of the population living below the international poverty line of US$1.90 Purchasing Power Parity (PPP) per day and 44.2 percent of its population below the national poverty line (World Bank, 2014). The national poverty rate decreased from 30% in 2011 to 24% in 2016 (World Bank, 2020a). Despite this progress, Ethiopia has a high Multidimensional Poverty Index (MPI) according to UNDP's multidimensional poverty estimates of the three equally weighted dimensions (health, education, and standard of living), about 69% of Ethiopia's population is multidimensionally poor while an additional 18.4% is classified as vulnerable to multidimensional poverty in 2019 (UNDP, 2021). This suggests that many Ethiopians, even if their income might be above the basic poverty line, still experience deprivations in health, education, and other essential areas. Evidence reveals that poverty is a driving cause for low human development (measured by the UN's Human Development Index (HDI)), chronic food insecurity, and high childhood undernutrition status in the country (FAO, IFAD, UNICEF, 2021). Regarding human development, although Ethiopia's Human Development Index (HDI) value (i.e., a composite measure of the life expectancy at birth, educational attainment, and gross national income) has increased by 66.1 percent from 0.292 in 2000 to 0.485 in 2019, the country is positioned at 173rd out of 189 countries and territories in 2019 (UNDP, 2020).

Ethiopia is among the most food-insecure countries in the world (Mohamed, 2017). Evidence shows that the Global Hunger Index (GHI) score of the country has declined from 55.9 (extremely alarming) in 2000 to 28.9 (serious) in 2019 (Grebmer et al., 2019). The state of chronic food insecurity and undernutrition is serious in the country and the GHI score ranked 90th out of 116 countries in 2021 (Grebmer et al., 2021). Recurrent droughts and other related disasters (such as outbreaks of crop and livestock diseases, floods, and land degradation), among others, are significant factors that enhance vulnerability to food insecurity, and undermine livelihoods in the country (Endalew et al., 2015). A prolonged drought combined with the disruption of health services due to instability, the COVID-19 pandemic, and lack of funding has left millions of people requiring urgent nutrition support in the country (OCHA, 2022). The overall progress in to fight against chronic food insecurity and undernutrition is decelerating while levels of undernutrition continue to be high and concerning in the country (Alliance, 2022).

The Government of Ethiopia (GOE) recognizes that ensuring optimal nutrition status is a critical component of realizing food security and economic prosperity (FDRE, 2021; USAID, 2018). In this regard, the government in collaboration with different partners had implemented programs and interventions in the past decades. To address the chronic food insecurity prevalence the Productive Safety Net Program (PSNP) has been implemented since 2005 in the country (Devereux et al., 2006). The PSNP attempted to provide cash or food to people who have predictable food needs in a way that enables them to improve their livelihoods and targeted to hardest-to-reach populations to build resilience against the causal factors of chronic food insecurity (Mastercard, 2019). In addition to PSNP, the Pastoralist Areas Resilience Improvement and Market Expansion (PRIME) was implemented from 2012 to 2019 to reduce chronic poverty and food insecurity among pastoral people (Smith et al., 2015). PRIME project interventions helped pastoralists (in Afar, Oromia, and Somali regions) to be prepared for environmental shocks that exacerbate chronic poverty and recurrent food insecurity by strengthening systems and individual capacities (USAID, 2019b). Moreover, the Agriculture Growth Program (AGP) has been implemented since 2011 to help reduce food insecurity, vulnerability, and environmental degradation (MOA, 2015). The first AGP (AGP I) focused on enhancing productivity and market access for key crop and livestock products within 96 targeted woredas in four agrarian regions (Berhane et al., 2013). The second AGP (AGP II) was implemented to contribute to sustainable agricultural transformation while improving the food and nutrition security situation of vulnerable groups in 157 woredas within seven geographic regions (MOA, 2015).

Furthermore, the GOE has long been committed to reducing childhood undernutrition and improving child survival. As a result, Ethiopia joined the Scaling Up Nutrition (SUN) movement in 2012 and endorsed the Seqota Declaration in 2015 with its high-level commitment to end childhood undernutrition by 2030 (FDRE, 2016). In 2018, the GOE developed a Food and Nutrition Policy to attain optimal nutritional status at all stages of life at a consistent level with a high quality of life, productivity, and longevity of life (FDRE, 2018). This policy aims to address childhood undernutrition with a coordinated and comprehensive approach to food security and nutrition based on evidence-based decision-making. Apart from the livelihood enhancement commitments, GOE has piloted, practiced, and updated the Health Extension Program (HEP) to improve child health and survival through primary health care since 2003 (FMOH, 2020). Furthermore, the first comprehensive National Child Survival Strategy (2005-2015) was developed in 2005, and the National Strategy for Newborn and Child Survival (2016-2020) was endorsed in 2015 with an ambitious goal of reducing under-five mortality by at least 29 deaths per 1000 children by 2020 (FDRE, 2016).

1.3. Statement of the Problem

Childhood undernutrition is a major indicator for monitoring the nutritional status and survival of children in many developing countries around the world (UNICEF, 2019b). Globally, 149.2 million under-five children suffered from stunting and 45.4 million under-five children were affected by wasting, of which, 13.6 million were severely wasted in 2020 (UNICEF/WHO/WORLD BANK, 2021). The number of children with stunting is declining in all regions except for Africa. In Africa, the number of stunted under-five children increased from 54.4 million in 2000 to 61.4 million in 2020 (UNICEF/WHO/WORLD BANK, 2021). In Ethiopia, although the proportion of stunted children declined from 52% in 2000 to 37% in 2019 (Figure 1-2), there were substantial regional variations in undernutrition indicators. Underweight was highest (36%) in the Afar region, while being stunted (47%) and wasted (23%) were highest in the Amhara and Somali regions of Ethiopia, respectively (Central Statistical Agency (CSA) [Ethiopia] & ICF., 2016). Therefore, it is important to note that the global number of stunted children is declining, Ethiopia has shown progress with a decrease from 52% in 2000 to 37% in 2019; however, significant regional variations persist within the country.

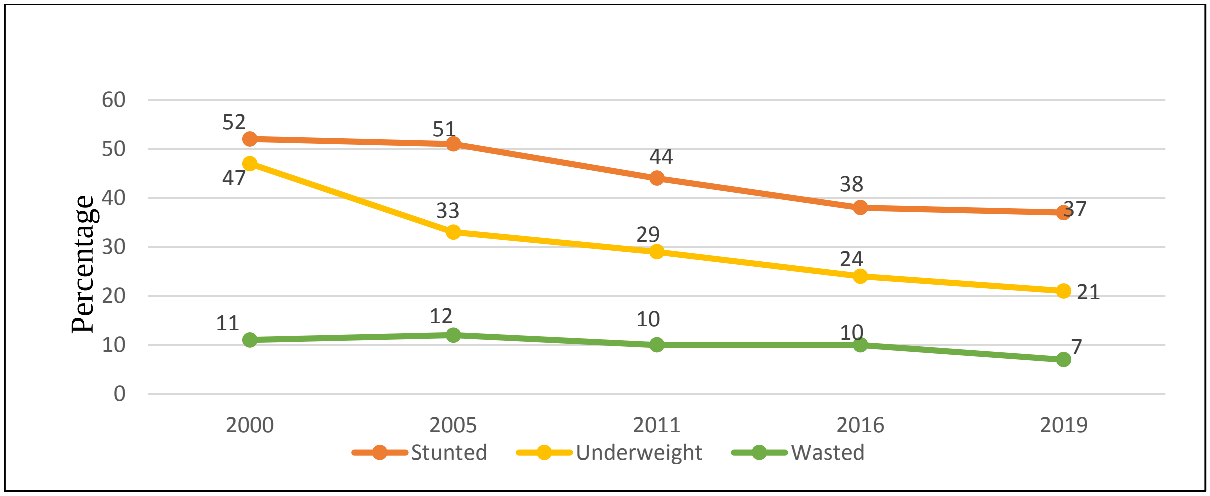


Figure 1-2: Prevalence of childhood undernutrition from 2000 to 2019, Ethiopia

Even though studies on trends in inequalities in childhood undernutrition are numerous across the world (Subramanyam et al., 2010; Rabbani et al., 2016; Vollmer et al., 2017; Krishna et al., 2018; Buisman et al., 2019; Akombi et al., 2019; Rizal & Doorslaer, 2019; Angdembe et al., 2019; Mostafa, 2020; Asuman et al., 2020; Karlsson et al., 2021; Ribeiro-Silva et al., 2021; Shibre et al. 2021;), our knowledge of the trends in Ethiopia is limited due to absence of large scale studies (Yayo, 2021; Zegeye et al., 2021). However, most of these empirical evidences focused on trends in inequalities in childhood undernutrition and considered only single indicators. Besides, these studies were also limited in scope and did not examine the contributing factors considering both multilevel and decomposition techniques.

Childhood anemia is another major indicator of child survival that causes child mortality and morbidity in many developing countries (WHO, 2011b). The global number of children aged 6-59 months with anemia declined slightly from 296 million in 2000 to 269 million in 2019 (Stevens et al., 2022a). In East Africa, the proportion of children aged 6-59 months with anemia declined from 68% in 2000 to 53% in 2019. In Ethiopia, the trend of anemia among children aged 6–59 months declined from 54% in 2005 to 44% in 2011 but increased to 56.6% in 2016 (Central Statistical Agency (CSA) [Ethiopia] & ICF., 2016). The Somali Region had the highest level of childhood anemia (83%), followed by the Afar region (75%); and the Amhara region has the lowest anemia prevalence among children (42%)(Central Statistical Agency (CSA) [Ethiopia] & ICF., 2016).

Although previous studies (Yang et al., 2018; Nguyen et al., 2018; Sunguya et al., 2020; Sun et al., 2021) conducted to investigate the trends in inequality in childhood anemia in developing countries, they did not consider the hierarchal nature of data for assessing the factors associated with childhood anemia using multilevel analysis approach to explore the effects of individual, household, and community characteristics. In addition, none of them quantified the contributions of observed and unobserved heterogeneity at the individual, household, and community levels through decomposition techniques.

Moreover, all countries have committed to reducing under-five mortality to 25 or less and newborn mortality to 12 or less per 1000 live births by 2030. However, under-five mortality remains high at global, regional, and national levels. Globally, 5.2 million under-five children's deaths per 1000 children were estimated in 2019 alone. Of these, more than half (55%) of the global under-five deaths occurred in the SSA region, and 49% of all under-five deaths are also concentrated in five countries, including Ethiopia (Sharrow et al., 2022). In Ethiopia, although under-five mortality declined in the past two decades, evidence shows that the rate is still high (see Figure 1-3). Substantial regional variation was also observed with the lowest U5MR (39 deaths per 1000 children) in Addis Ababa and the highest U5MR (125/1000) in the Afar region in 2016 (Central Statistical Agency (CSA) [Ethiopia] & ICF., 2016).

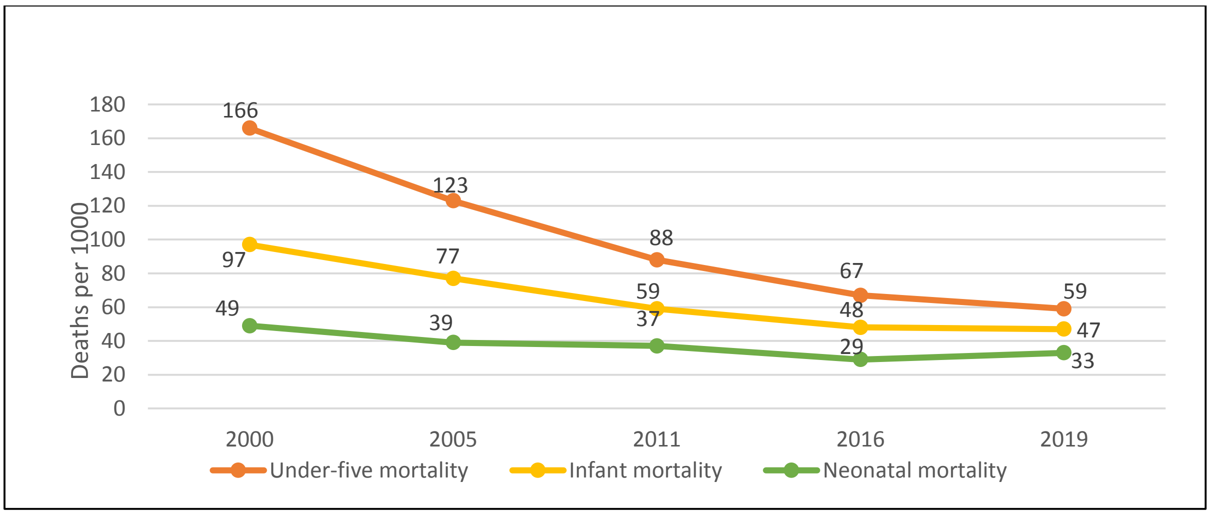


Figure 1-3:Trends of childhood mortality rates from 2000 to 2019, Ethiopia

Previous studies conducted in developing countries (Sreeramareddy et al., 2013; Hodge et al.,2014; Chao et al., 2018; Sastry, 2020; Eozenou et al., 2021) examined trends in inequality in under-five mortality. However, none of them employed multilevel analysis to explore the effects at individual, household, and community levels. In addition, none of them quantified the contribution of observed and unobserved heterogeneity of determinants through decomposition analysis.

Furthermore, the prior studies (Melli & Waldman, 2009; Assaf & Pullum, 2016; Li et al., 2017; Akombi et al., 2019; Abraha et al., 2020; Adeyinka et al., 2020; Aguilera et al., 2020; Hasan et al., 2021; Shibre et al., 2021) have examined trends in inequalities in one or two indicators of child survival. However, the major indicators and key drivers of inequality contributing to inequalities in child survival have not been previously well documented in Ethiopia. Thus, this thesis seeks to redress the paucity of information on the major indicators of inequalities in child survival based on key drivers of inequality using the five waves of EDHS data (2000 to 2019). Moreover, the present thesis estimated the population level attributable risk factors i.e., the proportion of reduction in the three outcomes (namely, childhood mortality, undernutrition, and anemia) by removing the risk factors.

Finally, although the previous studies conducted in Ethiopia have examined spatial analysis of child survival indicators, almost all of these focused on a single indicator of child survival. To the best of our knowledge, the spatial disparity of childhood anemia, undernutrition, and under-five mortality was not well documented in the country. Therefore, the present study attempts to redress the literature gap by assessing the spatial variability of childhood undernutrition, and anemia under-five mortality in Ethiopia.

1.4. Objectives of the Thesis

The general objective of the present thesis is to examine trends and key predictors of inequalities in three major indicators of child survival (under-five mortality, undernutrition, and anemia) in Ethiopia for the period 2000 to 2019. The specific objectives of the study are:

i. To explore the most dominant drivers of inequalities of childhood undernutrition, anemia, and mortality in Ethiopia;

ii. To assess levels and trends in socioeconomic inequalities in childhood undernutrition in the country;
iii. To examine trends in regional inequalities in childhood anemia in the country;
iv. To examine residential inequalities in childhood mortality in the country;
v. To explore trends in maternal education-based inequalities in under-five mortality in the country;
vi. To estimate the proportion of under-five children that could have been prevented from childhood undernutrition, anemia, and under-five mortality by removing modifiable risk factors; and
vii. To assess spatial clustering of childhood anemia, undernutrition, and under-five mortality in the country.

1.5. Research Questions

The following questions warrant a critical and in-depth investigation in the present study:

a) What are the most dominant drivers of inequalities in child survival in Ethiopia in the past two decades?
b) What are the levels and trends of socioeconomic inequalities in childhood undernutrition in Ethiopia over the last two decades?
c) What is the trend of regional inequalities in childhood anemia in the country?
d) What are the key factors that explain the rural-urban, intra-rural, and intra-urban gaps in child mortality in the country?
e) What is the level and extent of trends in maternal education-based inequalities in under-five mortality in the country?

f) How much is the proportional reduction in childhood undernutrition, anemia, and under-five mortality by removing the key risk factors?

g) Is there any evidence of spatial pattern and clustering of childhood undernutrition, childhood anemia, and under-five mortality in the country?

1.6. Significance of the study

The rationale for conducting the present thesis is twofold. First, as the primary focus of this thesis is to examine the inequalities in child survival using comprehensive health inequality indicators from nationally representative data (EDHS 2000 to 2019), the findings may be useful on a national scale in assessing the progress in the fight against morbidity and mortality among children. Thus, it can inform planners and policymakers at both the national and regional levels. The findings from the thesis would benefit organizations working on child health in their planning, geographic targeting, and monitoring and evaluating programs. The study also suggests appropriate interventions and strategies for achieving child survival to meet the SDGs targets by 2030. Secondly, over the past few years, there has been a growing interest in studies focusing on health inequalities, particularly in developing countries. Results obtained from this thesis, including the published articles in peer-reviewed international journals, will add to the body of knowledge and contribute to the discourse on issues of health inequalities among disadvantaged populations; a topic of growing importance in Ethiopia and Sub-Saharan Africa.

1.7. Scope of the Study

Although the main purpose of the present study is to assess inequalities in child survival in Ethiopia, it does not explicitly cover the three newly emerged regional states (Sidama, South West, and Central Ethiopia) of Ethiopia. The study has mainly focused on examining trends and key predictors of inequalities in three major indicators of child survival in Ethiopia for the period 2000 to 2019. The present work was merely based on women respondents aged 15-49 years with under-five children (aged 0-59 months).

1.8. Definitions of Key Terms

Definitions of the key operational terms are presented as follows:

- **Anemia** (childhood anemia) is defined as a condition where a child has an insufficient hemoglobin level (<110g/l)(WHO, 2011a) to provide adequate oxygen to body tissues (Kejo et al., 2018:9).
- **Anthropometric failure** is defined as a combined burden of stunting, underweight and/or wasting (Mejía-Guevara et al., 2018:3).
- **Child survival** refers to both childhood morbidity (undernutrition, and anemia) and mortality (Mosley & Chen, 1984).
- **Composite Index of Anthropometric Failure (CIAF)** is an index used to assess the overall burden of childhood undernutrition (i.e., stunting, underweight and/or wasting) (Nandy et al., 2005).
- **Inequality** in child survival refers to the existence of disparity on likelihood of reaching the age of five due to variations in socioeconomic status, geographical location, or other demographic factors (Mberu et al.; 2023).
- **Undernutrition** is defined as insufficient intake of energy and nutrients to meet an individual’s needs to maintain good health (Maleta, 2006:1).

1.9. Organization of the Thesis

The thesis is organized into 11 chapters. Chapter One covered the background of the thesis, where the contents of the statement of the problem, objectives, significance, and scope of the thesis were discussed. In Chapter Two, relevant literature relating to trends and inequalities in childhood undernutrition, childhood anemia, and under-five mortality, as well as the conceptual framework of the thesis, are reviewed and discussed. The third chapter discusses the general methodology of the thesis. Chapters four to ten constitute the research papers and are discussed in the subsequent seven chapters. The fourth chapter presents the most dominant drivers of inequalities in child survival in Ethiopia. Chapter Five discusses the levels and trends in socioeconomic inequalities in childhood undernutrition in the country. Chapter Six deals with trends in regional inequalities in childhood anemia in Ethiopia. Chapter Seven discusses residential inequalities in child mortality in the country. Chapter Eight also deals with trends in maternal education inequalities in under-five mortality. Chapter Nine explored the proportion of under-five children prevented from undernutrition, anemia, and death if all inequality risk factors were removed. In Chapter 10, the spatial variability of childhood undernutrition, anemia, and under-five mortality in Ethiopia is discussed. Chapter 11 summarizes the major findings of research papers, discusses the author's reflections on the seven studies of the present thesis, and highlights the policy implications and future works. Supplementary tables, figures, the first page of published papers, and ethical approval letters are annexed.

CHAPTER TWO

LITERATURE REVIEW

2.1. Drivers and Trends of Inequalities in Child Survival

2.1.1. Key Drivers of Inequality in Child Survival

To assess inequality in child survival, it is important to understand the key drivers of inequality, i.e., the underlying factors that create disparities in child survival. There are many studies that assessed inequality in child health outcomes, including childhood morbidity and mortality. However, the section contains only the very relevant studies conducted in the developing countries context. Evidence showed that there are many inequality drivers to describe health inequality, including education, social class, sex, geographic distribution, place of residence, and ethnic background characteristics that could distinguish population minority subgroups (WHO, 2013). In addition, economic status, parents' education level, sex of child, and area of residence are also considered as the main inequality dimensions used to assess inequalities in child health outcomes)(WHO, 2020a).

In general, a socioeconomic status which is mostly measured by wealth index and educational status has been identified as key inequality indicator for assessing inequalities in child health outcomes (Mulholland et al. 2008; Bado & Susuman, 2016; Ekholuenetale et al., 2020; Eozenou et al., 2021; Yayo, 2021). For example, Eozenou et al (2021) assessed socioeconomic inequalities in two child health outcomes (under-five mortality and stunting) based on household wealth status in low- and middle-income countries. Besides, Mulholland and colleagues' work provides evidence for the wealth index as a key driver of inequality in child survival along with geographic distribution or regions (Mulholland et al., 2008). A study conducted in Nigeria (Akeju et al., 2021) also examined regional variation as a key inequality indicator for child survival. Bado and Susuman (2016) also documented maternal education as a key inequality driver for child survival.

Most previous studies (Forde & Tripathi, 2018; Balaj et al., 2021; Zegeye et al., 2021; Agbadi et al., 2021) also examined inequalities in child mortality using five key inequality indicators. For example, a global meta-analysis examined inequalities in child mortality based on maternal and paternal education (Balaj et al., 2021). According to Balaj et al.'s assessment, both maternal and paternal education status could be identified as key inequality indicators. Another meta-analysis (Forde & Tripathi, 2018) explored the association of place of residence and under-five mortality in middle and low-income countries and found place of residence as the main inequality indicator. A study conducted in Yemen (Zegeye et al., 2021) also examined socio-econmic status, place of residence, and child-sex based inequalities in infant mortality. Zegeye et al.(2021) found household wealth index, maternal education, place of residence and child sex as inequality indicators drivers of inequality. A study conducted in Ghana examined trends in under-five mortality based on five inequality dimensions, including geographic location, household wealth index, maternal education, place of residence, and child sex (Agbadi et al., 2021).

Similarly, in terms of inequalities in childhood undernutrition, most previous studies (Ekholuenetale et al., 2020; Hasan et al., 2020; Alao et al., 2021; Yayo, 2021) used household wealth index, maternal educational status, geographic distribution or region as key inequality indicators. In this regard, a global meta-analysis examined economic inequalities in malnutrition and provided evidence that the prevalence of malnutrition varies by levels of absolute economic status (Alao et al., 2021). Another study conducted in sub-Saharan Africa (SSA) examined inequalities in childhood malnutrition based on household asset-based wealth index and mother's educational attainment (Ekholuenetale et al., 2020). In Bangladesh, Hasan and his colleagues explored socioeconomic inequalities in child malnutrition using the wealth index, maternal education, and regional distribution (Hasan et al., 2020). In Ethiopia, a study examined the dynamics of inequalities in child undernutrition and identified wealth index and mother's education as major contributors to inequality (Yayo, 2021).

Likewise, there is a dearth of studies (Hasan et al., 2021; Endris et al. 2021; Wang et al. 2021) investigating inequalities in childhood anemia using major socioeconomic inequality indicators. For example, a study conducted within 35 low and middle countries (Hasan et al., 2021) examined geographical variations, trends, and projections in prevalence of childhood anemia and subpopulation levels. Hasan et al's. work revealed that the prevalence of child anemia varies across the mother's education and age, child sex, wealth quintiles, and place of residence. In addition, Wang et al. (2021) explored inequalities in childhood anemia and identified geographic distribution, child sex, and household economic status as inequality dimensions in Mozambique. In Ethiopia, Endris et al.'s (2021) assessment provided evidence for geographic distribution, wealth index, maternal education, and place of regions as key drivers of inequality of anemia among children aged 6-59 months.

While existing research in developing countries highlights socioeconomic status and location as key factors in child survival inequality, but previous research often examines single health issues in isolation. Advanced analysis techniques are seldom used, and gaps exist in understanding the key drivers in child survival in Ethiopia.

2.1.2. Trends in Inequalities in Childhood Undernutrition

In a developing country like Ethiopia, the existing socioeconomic inequality within countries seems to be an obstacle to the improvement of childhood nutritional status among under-five children. Thus, studying trends in inequalities in childhood undernutrition over time is instrumental for monitoring the progress and it ignites light on the potential benefits and adverse effects on vulnerable groups of the population. Assessing trends in childhood undernutrition also allows us to review the population and socioeconomic policies and their implementation under public health perspectives. Although studies on trends in inequalities in childhood undernutrition are numerous across the world (Subramanyam et al., 2010; Rabbani et al., 2016; Vollmer et al., 2017; Krishna et al., 2018; Buisman et al., 2019; Akombi et al., 2019; Rizal & Doorslaer, 2019; Angdembe et al., 2019; Mostafa, 2020; Asuman et al., 2020; Karlsson et al., 2021; Ribeiro-Silva et al., 2021; Shibre et al. 2021;), our knowledge of the trends in Ethiopia is limited due to absence of large scale studies (Yayo, 2021; Zegeye, et al., 2021).

A multi-country study (Vollmer et al., 2017a) examined levels and trends of childhood undernutrition based on CIAF by wealth and education using evidence from 146 DHS data from 39 low and middle-income countries. Vollmer et al. provided evidence for persistent and even increasing socioeconomic inequalities in childhood undernutrition (Vollmer et al., 2017a). Another study in Brazil (Ribeiro-Silva et al., 2021) assessed the temporal trends and socio-demographic inequalities in malnutrition (stunting, wasting, overweight and double burden) in children attending primary health care services using the Prais-Winsten Estimation method based on data from Brazil's Food and Nutrition Surveillance System. They found a significant reduction in the prevalence of undernutrition among children in the most vulnerable subgroups although the prevalence of stunting and wasting persist alongside a disproportionate increase in the prevalence of overweight in these groups (Ribeiro-Silva et al., 2021).

Studies from Asian countries conducted in South Asia (Krishna et al., 2018a), Bangladesh (Rabbani et al., 2016; Mostafa, 2020), India (Subramanyam et al., 2010; Karlsson et al., 2021), in Indonesia (Rizal & Doorslaer, 2019), and Nepal (Angdembe et al., 2019) examined trends in inequalities in childhood undernutrition using different methods of analysis. For example, in South Asia, a study investigated trends in inequalities in stunting among under-two children using data from 1991-2014 DHS for Bangladesh, India, Nepal, and Pakistan based on a logistic regression model (Krishna et al., 2018a). The finding revealed that although stunting rates declined within the most deprived groups, socioeconomic differences were largely preserved over time and between wealth quintiles worsened. In Bangladesh, Mostafa (2020) examined inequalities and changes in the undernutrition of under-five children using data from the Bangladesh DHSs conducted in 2000 and 2014. Mostafa applied the Blinder-Oaxaca decomposition method to explore the magnitude and socioeconomic factors contributing to changes in inequalities in undernutrition and reported that although the prevalence of stunting and underweight declined and wasting increased, inequalities in undernutrition had increased during the study period. Moreover, Mostafa suggested that any program to mitigate inequalities of undernutrition between the poor and rich should address the prevailing socioeconomic inequalities in the country (Mostafa, 2020). Another study conducted in Bangladesh (Rabbani et al., 2016) explored trends and determinants of socioeconomic inequalities in stunting among under-five children using six-round Bangladesh DHS data from 1996 to 2014. They concluded that wealth and maternal factors were major contributors to observed socio-economic inequalities in child undernutrition and their changes over time (Rabbani et al., 2016). In India, Subramanyam et al. (2010) examined the trends in socioeconomic disparities in underweight and stunting among under-three children based on nationally representative three-round National Family Health Surveys data from 1992 to 2005 using multilevel modeling. Based on their assessment, social disparities in childhood undernutrition over the study period either widened or stayed the same (Subramanyam et al., 2010). A study in India (Karlsson et al., 2021) also examined trends in underweight, stunting, and wasting prevalence among under-five children based on living standards using four rounds of National Family Health Surveys from 1993 to 2016. Karlsson et al. found statistically significant decrement in states for stunting, wasting, and underweight using estimation of prevalence and average annual reduction considering the change in percentage points (Karlsson et al., 2021). In Indonesia, Rizal and Doorslaer (2019) examined trends in childhood stunting, its socioeconomic inequalities, and determinants based on two waves of Indonesia Family Life Surveys data using Erreygers concentration index and its regression-based decomposition. Rizal and Doorslaer found a significant reduction in the degree of absolute inequalities of stunting (Rizal & Doorslaer, 2019). In Nepal, Angdembe et al. (2019) explored trends and predictors of socioeconomic inequalities in childhood stunting using data from five rounds of Nepal DHS (1996-2016) based on decomposition analysis. Angdembe et al. found out that stunting was disproportionately concentrated in poor households and socioeconomic inequalities worsended from 1996 to 2016 (Angdembe et al., 2019).

In the sub-Saharan Africa region, for example, Asuman et al. (2020) assessed trends of socioeconomic inequalities in child stunting based on the 2000-2016 DHS data from ten countries of the region using decomposition analysis. They provided evidence for a persistent decline in the prevalence of stunting among under-five children across the study countries and trends in socioeconomic inequalities in stunting are mixed (Asuman et al., 2020). Another study also explained the fall in child stunting in seven Sub-Saharan African countries using the decomposition analysis method (Buisman et al., 2019). Other previous studies conducted in Nigeria (Akombi et al., 2019) and Mauritania (Shibre et al.,2021) also examined trends in socioeconomic inequalities in childhood undernutrition. Akombi and his colleagues (2019) examined the trend in socioeconomic inequalities in childhood undernutrition (stunting, wasting, and underweight) based on data from Nigeria DHS using decomposition analysis. Shibre et al. (2021) assessed trends in socioeconomic, sex, and geographic disparities in childhood underweight in Mauritania based on data from MICSs from 2007 to 2015 using WHO HEAT techniques.

In Ethiopia, a study assessed the dynamics of inequalities in child undernutrition using three-round panel data from 2012 to 2016 collected by Central Statistics Agency (CSA) and World Bank, and applied concentration index and decomposition analyses (Yayo, 2021). Another study conducted in Ethiopia also investigated both the extent and overtime dynamics of stunting inequalities based on evidence from 2000 to 2016 EDHS data using the WHO HEAT approach (Zegeye, et al., 2021). However, both of the studies fail to address the hierarchal nature of data for assessing the factors associated with childhood undernutrition using a multilevel analysis approach to explore the effects of individual, household, and community characteristics.

Two major limitations stand out in the previous studies reviewed above. First, most of the aforementioned empirical evidence on trends in inequalities in childhood undernutrition focused on single indicators such as stunting or underweight. Secondly, these studies were also limited in scope and did not examine the contributing factors considering both multilevel and decomposition techniques.

2.1.3. Trends in Inequalities in Childhood Anemia

Recent studies (Endris et al. 2021; Hasan et al., 2021; Wang et al. 2021) provided evidence for the existing prevalence and inequalities in childhood anemia in developing countries. To have a better understanding of any progress on inequality in childhood anemia, it is crucial to explore trends in inequalities in childhood anemia. In this regard, very few studies (Yang et al., 2018; Nguyen et al., 2018; Sunguya et al., 2020; Sun et al., 2021) conducted to investigate the trends in inequality in childhood anemia in developing countries. For example, a multi-country study systematically evaluated the trends in socioeconomic inequalities and the prevalence of anemia among children and non-pregnant women using DHS data from 45 LMICs, including Ethiopia (Yang et al., 2018). They used both the slope index of inequalities and the relative index of inequality and found that the socioeconomic inequalities of anemia did not decrease among children within about 80% of LMICs. Recently, another multi-country study (Sun et al., 2021) conducted using DHS data from 53 LMICs examined trends in geographical disparity anemia among children and women at national and sub-national levels using Bayesian linear regression models.

At a country level, a study conducted in India examined changes in hemoglobin and anemia among children and women using two rounds of Indian National Family Health surveys from 2006 to 2016 (Nguyen et al., 2018). Similarly, a study conducted in Tanzania (Sunguya et al., 2020a) examined trends in regional disparity of child anemia based on geospatial and regression analysis using data from 2004 to 2016 DHS. According to Sunguya et al's assessment, anemia has declined among children over a decade although it remained high in relatively better food-producing regions.

In conclusion, the abovementioned studies did not consider the hierarchal nature of data for assessing the factors associated with childhood anemia using a multilevel analysis approach to explore the effects of individual, household, and community characteristics. In addition, none of them quantified the contributions of observed and unobserved heterogeneity at the individual, household, and community levels through decomposition techniques.

2.1.4. Trends in Inequalities in Under-five Mortality

To understand and monitor the changes in inequalities in under-five mortality, it is relevant to examine trends in inequalities in under-five mortality based on statistically examined key drivers of inequality. In this regard, trends in inequalities in under-five mortality received scholarly attention in the past decades in developing and sub-Saharan African (SSA) countries (Sreeramareddy et al., 2013; Hodge et al.,2014; Chao et al., 2018; Macharia et al., 2019; Sastry, 2020; Agbadi et al., 2021; Eozenou et al., 2021).

Previous studies conducted in developing countries (Sreeramareddy et al., 2013; Hodge et al.,2014; Chao et al., 2018; Sastry, 2020; Eozenou et al., 2021) examined trends in inequality in under-five mortality. A study (Eozenou et al., 2021) reported long-run trends in inequalities in under-five mortality along with stunting in 102 low and middle-income countries (LMICs) across six regions using DHS and Multiple Indicator Cluster surveys (MICS). Eozenou and his colleagues have shown a clear association between socioeconomic inequalities and health inequalities; and the nonexistence of a strong correlation between changes in health inequalities and income growth. A systematic review conducted for 137 LMICs also assessed estimated country-year-specific under-five mortalities by wealth index based on household wealth indices using a Bayesian statistical model (Chao et al., 2018). According to Chao and colleagues, in all LMIC (excluding

China) the absolute disparities in under-five mortality rate between the poorest and richest households have narrowed significantly since 1990, whereas the relative difference has remained stable. To narrow a gap, they suggested targeted interventions that focus on the poorest population. In Brazil, Sastry (2020) examined trends in socioeconomic inequalities in under-five mortality for a period of 21 years (from 1970 to 1991) based on census data using a concentration index. According to Sastry's assessment, inequality in under-five mortality was declined by household wealth while the existence of substantial increment by mother's education. Another study in Indonesia, (Hodge et al.,2014) also examined trends in inequalities in under-five mortality using evidence from seven rounds of the Indonesian Demographic and Health surveys and direct estimation techniques. According to this study, the national rates of under-five mortality had declined following the reduction of absolute inequalities in clusters stratified by wealth, maternal education, and place of residence (Hodge et al.,2014). In Nepal, Sreeramareddy et al. (2013) assessed the time trends, and socioeconomic and regional inequalities in under-five mortality based on four DHS data from 1996 to 2011 using direct (life table) methods. Their findings revealed the existence of wide inequalities in wealth and education but changes in regional inequalities were marginal and irregular (Sreeramareddy et al., 2013).

From SSA countries, studies conducted in Ghana (Agbadi et al., 2021) and Kenya (Macharia et al., 2019) explored inequalities in under-five mortality. Agbadi and colleagues examined the trends of under-five mortalities from 1993 to 2014 using WHO's Health Equity Assessment Toolkit (HEAT) (Agbadi et al., 2021). Their findings provided evidence that children from uneducated mothers had consistently recorded the highest burden of under-five mortality (Agbadi et al., 2021). In Kenya, Macharia et al. (2019) examined sub-national variation and inequalities in under-five mortality since 1965 using ten household surveys and three census data from 1989 to 2014. The finding indicated a striking decline in the levels of inequality between sub-nationals over time with persistent disparities (Macharia et al., 2019).

To sum up, one of the critical gaps in the aforementioned studies is that nearly all of them did not consider the hierarchal nature of data for assessing the factors associated with under-five mortalities. To put it differently, none of them employed multilevel analysis to explore the effects at individual, household, and community levels. In addition, none of them quantified the contribution of observed and unobserved heterogeneity of determinants through the decomposition analysis.

2.2. Theoretical and Conceptual Frameworks

2.2.1. Theoretical Frameworks on Child Survival

This section highlights some theoretical frameworks formulated by different researchers and used to identify determinant factors and their relationships to child survival. Schultz (1984) is one of the researchers who developed the theoretical framework for child survival. Schultz's theoretical framework focused on the structural relationship between child survival and the individual's behavioral variables (including, nutrition and child spacing) along with both observed socioeconomic (like, cultural, social, economic, community, and religious) and biomedical (breastfeeding patterns and hygiene), and unobserved biological factors. In Schultz's framework, biomedical factors are modeled as having a direct effect on child mortality, while socioeconomic factors affect child survival indirectly as they work through the biomedical factors (Schultz, 1984). Likewise, Mosley and Chen (1984) classified the determinants of child survival as socioeconomic (such as cultural, social, economic, community, and regional determinants) and biomedical factors (such as maternal, environmental, nutrition, injuries, and personal illness). In Mosley and Chen's framework, socioeconomic factors are proposed to indirectly affect child survival as they pass through the proximate factors while proximate determinants affect child mortality directly (Mosley & Chen, 2003). Mosley and Chen categorized a set of proximate determinants into maternal factors (age, parity, and birth intervals); environmental hygiene factors (source of water and type of sanitation); nutrient deficiency (calories, protein, and micronutrient deficiency); injury (related to physical, burn and poisoning injury); and personal illness control (Immunization, bed net, etc.). In addition, Mosley and Chen also classified the socioeconomic determinants of child survival into individual, household, and community-level variables (Mosley & Chen, 2003; 1984).

2.2.2. Conceptual Framework of the Thesis

The conceptual framework of the thesis is adopted from the aforementioned analytical and theoretical frameworks (Mosley & Chen,1984; Schultz, 1984) and is further guided by empirical evidence (Baranwal et al., 2014; Mugo et al., 2018; Kasaye et al., 2019; Neupane et al., 2020; Gruchy, 2020; Ahmed et al., 2021). Figure 2-1 presents the conceptual framework used to explore child survival in Ethiopia. The conceptual framework was designed to link the geographic, socioeconomic, and demographic background determinants and child survival indicators (childhood undernutrition, anemia, and under-five mortality). In this conceptual framework, community level (administrative regions and place of residence); household level (household asset-based wealth status, household size, and sex of household head, source of drinking water, type of toilet, and types of cooking fuel); and individual level (both maternal and child background characteristics) determinants suggested to have direct effect on child survival indicators. The individual factors include maternal education, religion, employment status, age at childbirth, contraceptive use, birth interval and number of children ever born to mother, antenatal and postnatal care, initiation of breastfeeding practice, duration of breastfeeding, child sex, child size at birth, birth order, and diarrhea incidence and its treatment. Furthermore, child undernutrition status may affect childhood anemia, and both child undernutrition and anemia could affect under-five mortality (U5M) as well (Figure 2-1).

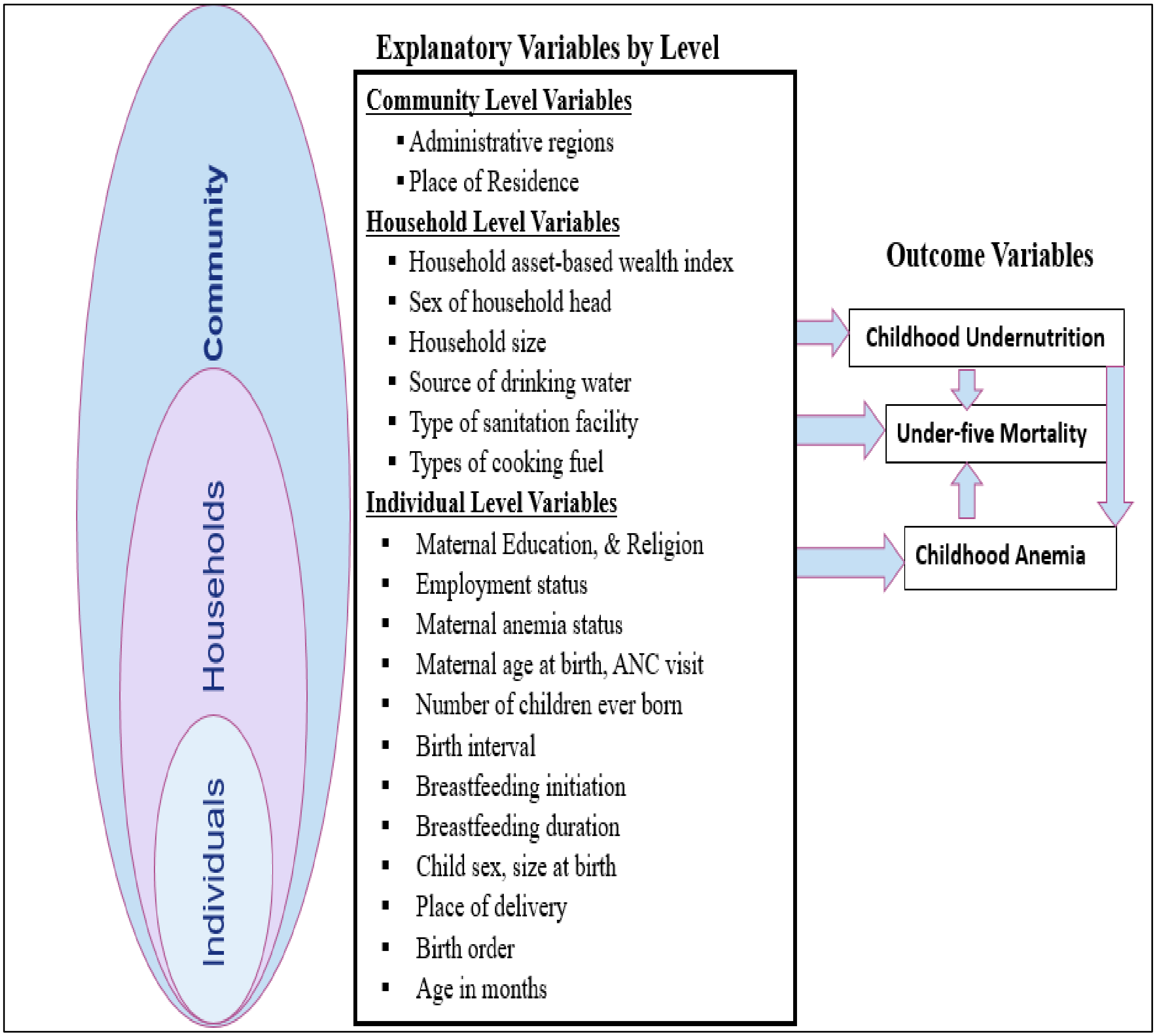


Figure 2-1: Conceptual framework adopted from Mosley & Chen (1984) and Schultz, (1984) and modified by the Author

CHAPTER THREE

METHODOLOGY

3.1. Data Sources of the Thesis

The study used the Ethiopian Demographic and Health Surveys (EDHS) data collected in five rounds (2000, 2005, 2011 & 2016, & the 2019 EMDHS) that provide demographic and health information of children below the age of five and their mothers of 15-49 years old. The EDHSs are large-scale and cross-sectional surveys conducted in a nationally representative sample of households from eleven regions of Ethiopia. All of the four EDHSs and the 2019 EMDHS used standardized questionnaires to collect detailed information on birth histories, health, nutrition, and related information on mothers and children. The birth history data allows for estimates of child mortality rates and examination of factors associated with under-five mortality, childhood undernutrition, and anemia at national and regional levels. All of the EDHSs also followed standard ethical procedures for ensuring the protection of respondents' privacy. Research participants have provided informed consent before the interview is conducted for all rounds of Ethiopian demographic and health surveys. The datasets were downloaded from the DHS website (http://dhsprogram.com) after securing online permission. Accordingly, data was extracted from the children recode dataset for each round and merged for analyses.

3.2. Study Design

The five rounds of EDHS cross-sectional surveys were conducted at regular intervals so that estimates of changes can be made at the aggregated or population level. Both repeated cross-sectional and ecological study designs were used for the thesis papers. A repeated cross-sectional study design is a study design where study participants are largely or entirely different on each sampling occasion (Caruana et al., 2015). Ecological study design is an observational study defined by the level at which data are analyzed at population or aggregated level (Levin, 2006). Repeated cross-sectional and ecological study designs were employed for the first four objectives and the last two objectives of the present thesis, respectively.

3.3. Sampling Procedure and Sample Size Determination

A two-stage stratified cluster sampling technique was used for all four rounds of the EDHS and the 2019 EMDHS. In the first stage, enumeration areas (EAs) (referred to as clusters) were selected. At this stage, 540, 540, 624, 645, and 305 clusters were selected in 2000, 2005, 2011, and 2016 EDHSs and 2019 EMDHS, respectively. In the second stage, systematic random sampling was applied to select households per each selected cluster using a sampling frame of the Ethiopian population and housing Census conducted in 1994 (for 2000 and 2005 EDHS), 2007 (for 2011 and 2016 EDHS), and sample frame created for 2019 Ethiopian Population and Housing Census (EPHC) for 2019 EMDHS). At the second stage, a representative sample of 14, 642; 14,500; 17,817; 16,650; and 9,150 households were selected for the five surveys, respectively. Accordingly, a sample of 10, 873; 9,861; 11,654; 10,641; and 5,753 under-five children were included in the Children Recode (KR) database in 2000, 2005, 2011, and 2016 EDHSs and 2019 EMDHS, respectively. The pooled dataset containing a total of 48,782 under-five children was used for analysis depending on the availability of outcome variables.

3.4. Study Variables

Outcome Variables: The study used three outcome variables. These include under-five mortality, childhood undernutrition, and childhood anemia. The outcome variables are determined as follows:

1. The outcome variable "child death" was assigned a value of 1 if the child died between 0 and 59 months and 0 if the child was alive at least until the age of 59 months.
2. Childhood nutritional status was assessed through the Composite Index of Anthropometric Failure (CIAF). CIAF was regrouped into seven subgroups using Z-score (Nandy et al., 2005): no failure, wasting only, wasting and underweight, wasting, stunting and under-weight, stunting and underweight, stunting only, and underweight only. Based on the CIAF, the outcome variable undernutrition was considered as undernourished and assigned a value of 1 if the child had any form of anthropometric failure, and 0 if the child had no failure
3. The outcome variable anemia was also recoded into a dummy variable where a child was considered anemic and assigned a value of 1 if the child had severe, moderate, or mild anemia level, and 0 if the child was not anemic.

Explanatory variables: Based on the review of the related literatures, and conceptual framework provided in Figure 2-1 above, the explanatory variables were refined and identified for each outcome variable discussed above. Table 3-1 presents selected key individual, household, and community- level determinants of child survival considering availability in the 2000, 2005, 2011, and 2016 EDHS and 2019 EMDHS datasets. Proximate determinants also consisted of other maternal, environmental and personal behavior and illness factors. To improve model efficiency for our analysis, we've grouped household size (small, medium, large, further as less than 6, and 6+), maternal age at birth (less than 19, 19 and above), and regional categories. This approach allows us to focus on broader trends and address potential limitations in the data, but acknowledges that comparisons to existing research with more granular categories might be affected.

Table 3-1: Description of the explanatory variables used for analysis

Variable name	Description
Community-level variables	
Administrative Regions	Nine old regions and two city administrations
Place of residence	1=Rural, 2= Urban
Household-level variables	
Sex of household head	1=male, 2= female
Household size	1=<4 (small), 2 = 4-6(medium), 3= 7 and above(large)
Wealth status	1= poorest, 2=poorer, 3=middle, 4=richer, 5=richest
Source of drinking water	1=improved, 0=unimproved
Type of toilet facility	1=improved, 0=unimproved
Types of cooking fuel	1= Clean fuel, 0= Solid fuel
Individual-level variables	
Sex of child	1=female, 0=male
Child size at birth	1=large, 2=average, 3=small
Birth order	1=1st, 2= 2nd – 4th, 3= 5th and above
Total number of children ever born to mother	1=less than 3, 2= 3+
Place of delivery	1=health Facility, 2=home
Mother's education	1=no education, 2=primary, 3= secondary+
Maternal anemia status	1=anemic, 2=non-anemic
Mother's religion	1=Orthodox Christian, 2=Muslim, 3=Others
Mother's employment status	1= employed, 0=unemployed
Mother's age at first birth	1= less than 19; 2=19 and above
Birth interval	1= < 24 months, 2= 24+ months
Antenatal care service use	1= < 4 visits, 2= 4+ visits
Postnatal care service use	0= No, 1= Yes
Early initiation of breastfeeding	1= Immediately after birth, 0= Not immediately
Breastfeeding duration	1= Less than 6 months, 2=6+ months
Immunization service use	1= immunized for age, 0 = not immunized for age
Diarrhea incidence	0=No, 1=Yes
ORS use	0=No, 1=Yes

For the convenience of data analysis, the eleven old administrative regional states of Ethiopia were categorized into three homogeneous groups: emerging regions (Afar, Somali, Benishangul-Gumuz, and Gambella), established regions (Amhara, Oromia, Harari, Southern Nations Nationalities and People's Region (SNNPR) and Tigray) and fully urbanized regions (Addis Ababa and Dire Dawa). Based on this category, the administrative regions were coded as 1=emerging, 2=established, 3=fully urbanized.

3.6. Data Analysis Approaches

STATA version 15.1 was used for data processing, recoding variables, and analysis. Before conducting descriptive analysis, about 3.2% of missing values were assessed and excluded from the analysis. The correlation matrix or variance inflation factor (VIF) was used to assess the presence of multicollinearity among the explanatory variables. An absolute correlation coefficient of less than 0.6 between two predictors (Senaviratna & Cooray, 2019) or a VIF value of <2.5 (Johnston et al., 2018) was used to test the absence of multicollinearity. All analyses were conducted based on weighted data as per DHS guidelines to adjust for differences in probability of selection and interview between cases in a sample or due to design.

Descriptive univariate analysis was conducted to describe the study population. Before conducting the inferential analysis, it is of paramount importance to understand the nature of data structure. In EDHS, individuals are nested within the household, and the households are also nested within the community. For such hierarchical data, conventional regression analysis provides biased estimates. This necessitates the use of multilevel or hierarchical modeling to separate the effects at individual, household, and community levels. A bivariate multilevel analysis was employed to select variables with p-value < 0.2 (Heinze & Dunkler, 2017) for multilevel multivariable analysis using a pooled dataset. A multilevel binary logistic regression was used for assessing the effects of individual, household, and community level factors on the outcome variables.

Further to examining determinants of childhood mortality, undernutrition, and anemia, the study employed multilevel analysis techniques. For multilevel logistic regression, the study used log-likelihood, Bayesian Information Criterion (BIC), and Akaike's Information Criterion (AIC) as well as Inter-class Correlation (ICC) to ascertain model goodness-of-fit and for selection of the best model. The multivariable hierarchical logistic regression analysis was performed in four stages using all the explanatory variables for each of the three child survival indicators. Firstly, a null model was constructed to test the feasibility of multilevel/hierarchical modeling without the inclusion of any variables (named Model 0). Secondly, the community-level variables were entered into the first model to assess their association with each outcome variable (named Model I). Thirdly, the household socioeconomic and demographic variables were added to the first model to assess their association with the community-level determinant variables and with the outcome variable (referred to as Model II). Fourthly, the individual level (socioeconomic, behavioral, and demographic) variables were added to the second model at the third stage to assess their association with the community and household level socioeconomic and demographic determinant variables and the outcome variable (i.e., Model III).

For each model, variables with p-values < 0.05 were discussed accordingly. In each of the above regression analyses, purposeful selection was used for model building. The approach is commonly used when the main purpose is risk factor modeling and not just prediction. In addition to significant explanatory variables, the purposeful variable selection procedure has the capability of retaining important confounding variables, resulting potentially in a slightly richer model (Zoran et al., 2008).

To establish inequalities in child survival (childhood undernutrition, childhood anemia, and under-five mortality), the study employed the Blinder-Oaxaca and multivariable decomposition techniques. For example, the Blinder-Oaxaca decomposition technique allows quantifying the gap between the advantaged and the disadvantaged groups (Fairlie, 2005; Jann, 2008; Sinning et al., 2008). Besides the decomposition analyses, Concentration and Thiel analyses were employed to depict inequalities in geographic and/or socioeconomic drivers. Moreover, Population Attributable Fraction (PAF) regression analysis was employed to estimate the proportion of childhood undernutrition, anemia, and under-five children prevented if all risk factors are removed. Furthermore, spatial autocorrelation, and hot and cold spot analyses were also applied to explore spatial patterns of childhood undernutrition, anemia, and under-five mortality in Ethiopia.

3.7. Ethical Considerations

For the original conduct of the five rounds of Ethiopian Demographic and Health Surveys (EDHSs), ethical approval was obtained from the ethical committee of the ICF and the national institutional review board (IRB). The enumerators obtained informed consent and authorization to anonymously use the data from all survey participants. For this study, permission was obtained to use the data from the DHS program (Annex I). In addition, the ethical approval was obtained from Addis Ababa University, College of Development Studies IRB (Annex II), and the present study solely involved analysis of publicly available secondary data that does not contain any identifiable information that links to the actual survey participants. The author also confirms that all methods were carried out by relevant guidelines and regulations.

CHAPTER FOUR

Exploring the most dominant drivers of inequalities in child survival in Ethiopia: Dominance Analysis

(The paper was published@ International Journal of Population Studies, *IJPS* 2023, 9(2), 427. https://doi.org/10.36922/ijps.427, and appeared as Negussie S.T. & Nigatu R.G.)

4.1. Background

Inequalities in child survival are a global public health concern (Brault et al., 2020; Cha & Jin, 2020). Although reducing inequalities in child survival is given due attention in Sustainable Development Goals (SDGs) (Yourkavitch et al., 2018), it is widespread at global, regional, and national levels (Sharrow et al., 2022). According to the World Health Organization (WHO), children in African region are 10 times more likely to die before their fifth birthday compared to children in the European region (WHO, 2022). Two regions, sub-Saharan Africa, and central and southern Asia, account for more than 80 percent of the 5.2 million under-five deaths, where sub-Saharan Africa remains the region with the highest under-five mortality (U5M) rate (a 1 in 13 rate) in the world in 2019 (WHO, 2020).

In Ethiopia, the U5M rate varies across the administrative regions, ranging from 74 deaths per 1000 live children in Afar to 29 deaths per 1000 live children in Addis Ababa (EPHI & ICF, 2021). Geographic inequality in under-five mortality was higher in Benishagul-Gumuz, followed by Amhara, Afar, Gambella, and South Nation Nationality and People's Region (Liyew et al., 2021). Inequality of anemia among under-five children also exists across regions in the country (Anteneh & Geertruyden, 2021; Endris et al., 2021). Inequalities in childhood undernutrition by administrative region (Yayo, 2021) and maternal education status (Bras & Mandemakers, 2022) are also documented in the country. Thus, inequality in child survival remains a challenge in the country to achieve SDG targets, specifically among more disadvantageous population groups and emerging regions (Dheresa et al., 2022).

Despite the marked improvement in the prevalence of U5M in Ethiopia, substantial inequalities in child health outcomes among the different socio-economic subgroups persist and progress is uneven. Hence, this paper attempts to answer the question "What are the most dominant drivers of inequalities in child survival in Ethiopia?" Knowing the dominating drives of inequality in child survival indicators is essential to identify how the inequalities can be minimized and/or prevented. In this paper, the child survival indicators refer to childhood undernutrition and anemia (Nkosi-Gondwe et al., 2021), and under-five mortality (Mosley & Chen, 1984).

To date, numerous studies (Agbadi et al., 2021; Alao et al., 2021; Balaj et al., 2021; Endris et al., 2021; Hasan et al., 2021; Wang et al., 2021a; Yayo, 2021; Zegeye, et al., 2021) have examined the determinants of inequality in child survival. However, these studies have used a regression modeling approach that is limited to identifying the relative importance of the determinants for predicting inequalities in child survival by applying the dominance analysis procedure. In addition, these studies have focused only on one or two child survival indicators, identifying the key drivers of inequalities in child survival indicators (i.e., childhood undernutrition, anemia, and U5M) remains limited. Therefore, this paper seeks to redress the paucity of information about the key drivers of inequalities in child survival indicators. The objective of this paper is to examine the most dominant, drivers of inequality in child survival indicators (undernutrition, anemia and under-five mortality) in Ethiopia.

4.2. Conceptual Framework

This study has mainly focused on five internationally conceptualized dimensions of inequality (World Health Organization (WHO) & International Center for Equity in Health, 2015). The five inequality dimensions (household wealth index, maternal educational status, place of residence, regional distribution, and child sex) were used as drivers of inequalities in child survival to construct a conceptual framework for this study. It is essential to understand that before birth, children whose parents live in a situation of socioeconomic and geographic vulnerability may have worse health outcomes than those who live in better situations (Pearce et al., 2019). How living conditions affect child survival are complex and more driven by socioeconomic inequalities (Rebouças et al., 2022). To identify the key drivers of inequality in child survival, it is crucial to understand the conditions under which children are born and live, and consider socioeconomic and geographic stratifications among population groups. In this regard, the five drivers of inequality could be grouped into socioeconomic (household wealth index, maternal educational status, and place of residence) and geographic (administrative regional distribution) stratifications (Houweling & Kunst, 2010) and the biological determinant (i.e., child sex) (Rebouças et al., 2022). The conceptual framework is derived from the conceptual model proposed by Mosley and Chen (1984) in studying child survival in developing countries. Mosley and Chen's model has been applied in the studies of inequalities in child survival in developing countries (Houweling & Kunst, 2010; Rebouças et al., 2022). For example, Houweling and Kunst used to investigate the effect of socioeconomic and geographic stratifications on inequality in child survival (Houweling & Kunst, 2010). Rebouças et.al also showed that inequalities in child survival are directly influenced by the biological conditions of the child (sex of the child) (Rebouças et al., 2022). Further, to consider the hierarchical nature of inequality drivers, the five drivers of inequality are grouped into community (administrative regions and place of residence), household (household wealth index), and individual levels (maternal education and sex of child).

4.3. The study setting

Ethiopia is one of the Sub-Saharan African countries with one of the highest burdens of U5M, ranking third in Africa and tenth in the world (Dheresa et al., 2022). Ethiopia is landlocked, sharing frontiers with Eritrea to the north and northeast, Djibouti to the east, Somalia to the east and southeast, Kenya to the south, and South Sudan and Sudan to the west (FAO, 2016). The country is ethnically and culturally diverse, and the second most populous country in Africa (USAID, 2021a), and among the least urbanized countries in the world, with 82% of the population living in rural areas (Bogale et al., 2022). Administratively, the regional states possibly vary in their level of economic development, socio-cultural, educational, and health service provision and settings (Bareke et al., 2022). Based on the development perspective, the former nine regional states and the two-city administrations are categorized into three: Emerging (Afar, Somali, Benishangul-Gumuz, and Gambella); Established (Tigray, Amhara, Oromia, Southern Nation Nationalities and People (SNNP), and Harari) and fully urban (Addis Ababa and Dire Dawa city administrations) (Bareke et al., 2022; Tesema & Braeken, 2018). The emerging regions are drought-affected areas, pastoralists, and marginalized in terms of basic infrastructure development (Bareke et al., 2022).

Ethiopia is a low-income country having a gross domestic product (GDP) per capita of US$ 855,80 in 2019 (Tangcharoensathien et al., 2022), making it one of the poorest countries in the world (World Bank, 2020a). About 69% of Ethiopia's population is multidimensionally poor in 2019 (UNDP, 2021). The multidimensional child poverty incidence and intensity varies across regions and places of residence in the country, where the multidimensional child poverty incidence ranges from 23 % (lowest) in Addis Ababa to 98 % (highest) in the Somali region (CSA and UNICEF, 2020). Likewise, the monetary child poverty incidence and depth varies across regions and areas with the highest incidence in Afar (39 percent) and Amhara regions(37 percent) and the lowest in Harari city administration(14 percent); and considerably higher in rural areas (31 percent) compared to large city areas (23 percent) (CSA & UNICEF, 2020).

Regarding child survival policies, the Government of Ethiopia has realized pro-poor policies and strategies for child survival (Rono et al., 2022). Since 2003, the country has implemented the Health Extension Program (HEP) to improve child survival through primary health care (MOH, 2020). In addition, the country endorsed the first comprehensive National Child Survival Strategy (2005-2015), and the second strategic document of National Strategy for Newborn and Child Survival (2016-2020) in 2005 and 2015, respectively (FDRE, 2016). The Government of Ethiopia (GoE) has demonstrated a strong policy commitment to nutrition through the development of a National Nutrition Strategy (NNS) in 2008, followed by the implementation of National Nutrition Program I (2008-2015) and National Nutrition Program II (2016-2020) (Kennedy et al., 2020). Ethiopia also joined the Scaling Up Nutrition (SUN) movement in 2012 and endorsed the Seqota Declaration in 2015 with its high-level commitment to end childhood undernutrition by 2030 (FDRE, 2016). Furthermore, GoE has developed the Food and Nutrition Policy to attain optimal nutritional status at all stages of life (FDRE, 2018). As a result, the country has achieved remarkable progress in child survival in the past two decades, but such achievements have been disproportionate across socioeconomic and geographic stratifications, particularly for the most marginalized population groups.

4.4. Data and Methods

4.4.1. Study Design and Data Sources

A retrospective cross-sectional study design is used for the present study, using the five rounds of Ethiopian Demographic and Health Surveys (EDHSs conducted from 2000 to 2019 in Ethiopia. The study used nationally representative data from the five rounds of Ethiopian Demographic and Health Survey (EDHS) data collected from year 2000 to 2019. The datasets were downloaded from the DHS website (http://dhsprogram.com) based on secured online permission. The study used children's files that contain information about socioeconomic, demographic, and geographic characteristics of under-five children, their parents, households as well as their communities. The pooled five rounds of EDHS data comprised 48,422 under-five children used for the analysis. The outcome and explanatory variables were extracted from pooled data.

4.4.2. Study Variables

Outcome Variables: Childhood undernutrition, childhood anemia, and under-five mortality were the three outcome variables of the study. Childhood undernutrition status was categorized as undernourished and coded as 1 if a child had any form of anthropometric failure, and as nourished with an assigned value of 0, if the child had no failure. Childhood anemia was recoded into a dummy variable where a child was considered to be anemic and assigned a value of 1 if the child had severe, moderate, or mild anemia level, and 0 if the child is not anemic. Under-five mortality was coded as a dummy variable and assigned value of 1 if the child died between 0 and 59 months, and 0 if the child was alive at least until the age of 59 months (Central Statistical Agency (CSA) [Ethiopia] & ICF., 2016).

Predictor variables: Five internationally accepted dimensions of child survival inequalities (World Health Organization (WHO) & International Center for Equity in Health, 2015) were used as predictor variables in this paper. Henceforth, the predictor variables are referred to as inequality drivers. The interlink among these predictor variables was also depicted in the conceptual frameworks shown above. Table 4-1 presents the description of the inequality drivers. The household wealth index was categorized into five quintiles and regrouped as Poor (the first two quintiles) and Non-poor (the last three quintiles). Education was used to reflect the level of education attained by a child's mother, and grouped into two subgroups: No education, and Primary and above. Place of residence (rural or urban) and child sex (female or male) each of them classified into two subgroups. The old nine regional states and the two-city administrations were regrouped into three: Emerging (Afar, Somali, Benishangul-Gumuz, and Gambella); Established (Amhara, Oromia, Southern Nation Nationalities and People (SNNP), Tigray and Harari) and Urban (Addis Ababa and Dire Dawa city administrations) (Bareke et al., 2022) (Table 4-1).

Table 4-1: Description of the inequality drivers

Inequality drivers	Description
Sex of child	1=Female; 2=Male
Maternal education	1=No education; 2=Primary+
Household wealth index	1= Poor; 2=Non-poor
Place of residence	1=Rural; 2= Urban
Regional category	1= Emerging; 2=Established; 3= Urban

Source: Authors own description.

4.4.3. Statistical Analysis

To reduce bias, children with missing height/length, weight, and unknown responses were excluded from the analysis of undernutrition. For childhood anemia analysis, data from children aged 6-59 months were used. Descriptive statistics were used to describe the background characteristics of the study participants and the key variables. A correlation matrix was used to detect multicollinearity and an absolute correlation coefficient of less than 0.6 was observed among predictors indicating the absence of multicollinearity (Senaviratna & Cooray, 2019). Logistic regression was employed to identify significant drivers of inequality in child survival. Bivariate logistic regression analysis was used to establish the strength of the relationship between inequality drivers and the outcome variables. Further, to determine the relative importance of each predictor to the outcomes, we used the dominance analysis. Dominance analysis is a technique developed to estimate the relative importance of all predictors in the logistic regression model with an outcome variable (Azen & Traxel, 2009). Dominance analysis relies on estimating the regression values of all possible combinations of predictors and measures relative importance by doing comparisons of all predictors in the model as they relate to an outcome variable (Tighe & Schatschneider, 2014). Dominance analysis allows us to identify the relative dominance of the predictors (Azen & Traxel, 2009; Lee & Dahinten, 2021). We also conducted a sensitivity analysis to predict the outcome of a decision given a certain range of variables (Annex IV). All analyses were weighted based on DHS guidelines (Croft et al., 2018) using STATA version 15.

4.5. Results

4.5.1. Characteristics of the study participants

Table 4-2 presents the background characteristics of the study participants by inequality dimensions. More than half (52.64%) of children were born to mothers residing in established regions, and majority (82.88%) of children were born in rural areas. More than half (51.21%) of children were born in households grouped as poor wealth status. Table 2 also shows that most

(70.63%) of the children were born to uneducated mothers, and a little more than half (51.25%) of the children were males. About 51% and 55.06% of children were undernourished and anemic, respectively, and more than eight percent of children were reported to have died (Table 4-2).

Table 4-2: Background characteristics of study participants, Ethiopia, 2000-2019.

Inequality drivers	N	%
Community level drivers		
Regional Category		
Established	25,489	52.64
Emerging	18,321	37.84
Urban	4,612	9.52
Place of residence		
Rural	40,131	82.88
Urban	8,291	17.12
Household level driver		
Household wealth status		
Poor	24,503	51.21
Non-poor	23,347	48.79
Individual level drivers		
Maternal education		
No education	34,200	70.63
Primary+	14,222	29.37
Sex of child		
Male	24,814	51.25
Female	23,608	48.75
Outcome variables		
Undernutrition (N=35,688)		
Nourished	17,602	49.32
Undernourished	18,086	50.68
Anemia* (N=19,699)		
Anemic	10,847	55.06
Not anemic	8,852	44.94
Under-five mortality (N=48,422)		
No	44,485	91.87
Yes	3,937	8.13

* *Anemia data was not collected in 2000 and 2019 EDHSs.*
Source: Authors analysis using EDHS 2000-2019.

4.5.2. Results of Bivariate Logistic Regression

Table 4-3 presents results from the bivariate analysis to assess the association between the outcome variables and inequality drivers. The Table shows that all socioeconomic (place of residence, household wealth status, and maternal education), geographic (region), and biological (sex of child) inequality drivers were significantly associated with childhood undernutrition (at p<001) and under-five mortality (at p<05). Likewise, region, place of residence, household wealth status, and maternal education status had a statistically significant association with childhood anemia.

The findings of the bivariate regression analysis revealed that regional category, place of residence, household wealth status, maternal education, and child sex were potential and significant drivers of inequality in childhood undernutrition, childhood anemia, and under-five mortality (U5M) to explore through multivariable analysis (Table 4-3).

Table 4-3: Bivariate association between inequality drivers & outcome variables, Ethiopia, 2000-2019

Inequality drivers	**Odds ratio**	**SE**	**[95% LB UB]**	**chi^2**
		Undernutrition (N=35,688)		
Regional category (Urban)				14.33
Established	2.580	.649	[1.576, 4.225] ***	
Emerging	2.022	.493	[1.255, 3.259] ***	
Place of residence (Urban)				350.61
Rural	1.916	.067	[1.790, 2.051] ***	
Wealth Status (non-poor)				290.90
Poor	1.491	.035	[1.424, 1.560] ***	
Maternal education (Primary+)				392.42
No education	1.647	.042	[1.568, 1.731] ***	
Child Sex (Male)				24.70
Female	1.114	.024	[1.068, 1.163] ***	
		Anemia (N=19,699)		
Regional category (Established)				4.94
Emerging	1.98	.613	[1.079,3.634] **	
Central	1.32	.531	[0.602, 2.908]	
Place of residence (Urban)				102.09
Rural	1.639	.080	[1.489, 1.804] ***	
Wealth Status (non-poor)				119.86
Poor	1.424	.046	[1.337, 1.517] ***	
Maternal education (Primary+)				12.26
No education	1.128	.039	[1.055, 1.207] ***	
Child Sex (Male)				0.24
Female	1.015	.031	[0.956, 1.077]	
		Under-five Mortality (N=48,422)		
Regional category (Central)				7.92
Established	1.357	.175	[1.053, 1.748] **	
Emerging	1.421	.180	[1.109, 1.83] ***	
Place of residence (Urban)				28.59
Rural	1.353	.076	[1.211, 1.511] ***	
Wealth Status (non-poor)				18.58
Poor	1.169	.042	[1.089, 1.255] ***	
Maternal education (Primary+)				63.68
No education	1.395	.058	[1.285, 1.514] ***	
Child Sex (Male)				43.70
Female	1.252	.042	[1.171, 1.338] ***	

**** p<.01, ** p<.05, * p<.1; LB=Lower boundary, UB= Upper Boundary*

Source: Author's analysis using EDHS 2000-2019

4.5.3. Results of Dominance Analysis

Table 4-4 depicts a dominance analysis of the drivers of inequality in child survival indicators. The analysis of the drivers of inequality revealed that maternal education, place of residence, and household wealth status were the three most dominant drivers of inequalities in childhood undernutrition, accounting for 83.48% of the predicted variance. Child sex was the lowest-ranked inequality driver in the dominance analysis, accounting for 1.61% of the predicted variance. In dominance analysis, the geographic predictor (region) was found to be the first-ranked dominant driver of inequalities in childhood anemia, accounting for more than half (50.56%) of the predicted variance. Dominance analysis also revealed that maternal education, child sex, and place of residence were the three top dominant drivers of inequality in under-five mortality, accounting for 89.3% of the predicted variance (Table 4-4).

Table 4-4: Dominance analysis of the outcome and inequality indicators in Ethiopia, 2000-2019

Inequality drivers	**Dominance statistics**	**Standardized* Dominance statistics**	**Ranking**
	Undernutrition (N=35,688)		
Region	0.0040	0.1459	4
Place of residence	0.0084	0.3030	2
Wealth Status	0.0057	0.2060	3
Maternal education	0.0090	0.3258	1
Child Sex	0.0005	0.0193	5
	Anemia (N=19,699)		
Region	0.0116	0.5056	1
Place of residence	0.0024	0.1041	3
Wealth Status	0.0075	0.3267	2
Maternal education	0.0014	0.0610	4
Child Sex	0.0001	0.0025	5
	Under-five mortality (N=48,422)		
Region	0.0001	0.0132	5
Place of residence	0.0010	0.1994	3
Wealth Status	0.0004	0.0522	4
Maternal education	0.0037	0.4158	1
Child Sex	0.0016	0.2778	2

*Standardized dominance statistics do not total to 1 due to rounding

Source: Author's analysis using EDHS 2000-2019

Moreover, we checked the ranking of the inequality drivers for a group of eight predictors by including three additional variables (sex of household head, maternal religion, and employment status) and found similar ranking results (Annex III). Furthermore, we also conducted the sensitivity analysis to explore the predictors' effect on undernutrition, anemia, and U5M using the five (region, place of residence, wealth index, maternal education, and child sex) and eight (region, place of residence, wealth index, maternal education, child sex, sex of household head, maternal religion and employment status) inequality predictors. However, the predictive power of the model was relatively better with the eight predictors compared to the model with the five predictors (Annex IV).

4.6. Discussion

This study examined associations between five inequality dimensions and three child survival indicators based on data pooled from five consecutive national surveys conducted in Ethiopia. The study identified the relative importance of the drivers of inequality in predicting inequality in child survival through dominance analysis. Maternal education, place of residence, and household wealth status were found to be the three key drivers of childhood undernutrition inequality. Dominance analysis also identified region, household wealth status, and place of residence as the three most dominant drivers of inequalities in childhood anemia in order of dominance. Furthermore, the dominance analysis results of this study underscored the influence of maternal education, child sex, and place of residence on existing inequalities in under-five mortality in the country.

Similar to previous studies, this study found that maternal education, place of residence, and household wealth index as the most dominant drivers of inequalities in childhood undernutrition (Alao et al., 2021; Ekholuenetale, Tudeme, et al., 2020; Hasan et al., 2020; Yayo Negasi, 2021). Thus, these findings highlight the importance of interventions and policies that enhance the socioeconomic and livelihood of uneducated, poor, and rural population groups to reduce inequalities in childhood undernutrition. Similar to the findings from other studies (Adeyinka et al., 2019; Ekholuenetale et al., 2022; Endris et al., 2021; Jember et al., 2021; Yadav & Nilima, 2021), the geographic location (region) was found to be a dominant driver of inequalities in childhood anemia. This result highlights the importance of implementation of interventions, especially targeting regional variations for accelerated reduction in childhood anemia. In addition, as in previous studies (Endris et al., 2021; Hasan et al., 2021; Wang et al., 2021a), the present study found that the household socioeconomic status measured by wealth index was another key driver of inequalities in childhood anemia. This indicates that the poor socioeconomic status of households could enhance the prevalence of childhood anemia, and thus improving the socioeconomic status of the poor can reduce inequality in childhood anemia.

The results of this study were consistent with other previous studies reporting maternal education, and place of residence as the key drivers of inequalities in under-five mortality (Agbadi et al., 2021; Balaj et al., 2021; Zegeye, et al., 2021). This finding signifies the importance of robust, and influencing policies and interventions for reducing inequalities in under-five mortality and improving the overall child survival through addressing urban-rural and maternal education gaps at community and individual levels.

The strengths of the present study were its large sample drawn five rounds of nationally representative cross-sectional surveys, and the use of dominance analysis to identify the key predictors of inequality in child survival indicators. There are some limitations in this study. Firstly, the findings show drivers that are associated with inequalities in childhood undernutrition, anemia, and under-five mortality and magnitude of associations but no causal interpretation of the results is implied here as the cross-sectional survey data preclude causal inferences. Secondly, although the study has included internationally accepted drivers of inequality, there would be other important drivers of inequality that are not included in this paper.

4.7. Conclusion

This study provides empirical evidence that region and place of residence (community level), household socioeconomic status (household level), and maternal education (individual level) were the most dominant drivers of inequality in child survival. The findings imply that reducing inequalities in child survival needs to start at a higher hierarchical structure (regional and residential levels), notwithstanding the importance of household and individual level influences. Further improving the socioeconomic status of the poorest households, prioritizing regions and rural areas with the highest needs, and improving maternal education levels would significantly reduce child survival inequalities in the country.

CHAPTER FIVE

Levels and Trends in Key Socioeconomic Inequalities in Childhood Undernutrition in Ethiopia: Evidence from the Ethiopian Demographic and Health Surveys 2000-2019

(The paper was published@ BMC Discover Social Science and Health (2023) 3:5| https://doi.org/10.1007/s44155-023-00034-4), and appeared as Negussie Shiferaw and Nigatu Regassa)

5.1. Background

Childhood undernutrition, which refers to a combination of stunting, wasting, and underweight (Ahmed et al., 2017), is an important public health indicator for monitoring child nutritional status and survival (Agho et al., 2019). Undernutrition is a public health problem in the developing world (Development Initiatives, 2021) and is highly associated with increased childhood deaths (Adedokun & Yaya, 2021). Nearly half of all deaths in under-five children are attributed to undernutrition (UNICEF, 2022). In addition, childhood undernutrition has adverse consequences on the development of children (Amir-Ud-Din et al., 2022) as it exposes children to reduced human capital in later life in terms of education, and cognitive development (Mwene-Batu et al., 2020).

Globally, 149.2 million under-five children are stunted (short for their age), 45.4 million under-five children are wasted (thin for their height) (UNICEF/WHO/WORLD BANK, 2021), and 85 million are underweight (thin for their age) in 2020 alone (WHO, 2021). Nevertheless, the prevalence of child undernutrition has shown improvement since 2000 (FAO, IFAD, UNICEF, WFP & WHO, 2022). While the prevalence of undernutrition showed slight improvement across many developing countries in the past two decades, evidence shows that substantial inequalities in childhood undernutrition among different population groups exists at regional and sub-regional levels (Ssentongo et al., 2021). The global burden of childhood undernutrition is mainly concentrated in low-income and lower-middle-income countries (Vollmer et al., 2017b). In 2020, nearly two-thirds of all under-five children with stunting and three-quarter of all children with wasting lived in lower-middle-income countries (UNICEF/WHO/WORLD BANK, 2021). In particular, more than half of all under-five children affected by undernutrition (including stunting, wasting, and underweight) lived in Asia and more than one quarter lived in Africa in 2020 alone (UNICEF/WHO/WORLD BANK, 2021; WHO, 2021). In addition, although the number of children with stunting is declining at the global level, it increased from 54.4 million in 2000 to 61.4 million in 2020 in Africa (UNICEF/WHO/WORLD BANK, 2021).

Among under-five children in 31 Sub-Saharan African countries (including Ethiopia), 26% of them were stunted, 21% were underweight, and 6% were wasted (Adedokun & Yaya, 2021). In Ethiopia, 37 % of under-five children were stunted, 21% underweight, and 7% were wasted (Ethiopian Public Health Institute (EPHI) [Ethiopia] and ICF., 2021). While there was a modest decline in the prevalence of undernutrition over the last two decades, the prevalence varies significantly across different population groups. Inequalities in undernutrition among children in Ethiopia occur due to several social, demographic, and economic factors. Education and income-based inequalities are commonly reported parameters (Mohammed et al., 2019; Fenta et al., 2020; Bekele et al., 2021; Zegeye et al., 2021).

Although the prevalence of childhood undernutrition has shown a significant decline based on estimates from the Demographic and Health surveys (Central Statistical Agency (CSA) [Ethiopia] and ICF., 2016; Ethiopian Public Health Institute (EPHI) [Ethiopia] and ICF., 2021), socioeconomic inequalities in childhood undernutrition continue to be a significant problem. Given most children are living in poorer and poorest households and nearly 85% are living in rural areas with little access to services, the extent of inequality could be significant. Thus, the situation necessitates evidence-based findings about the existing socioeconomic inequalities in undernutrition among children to support the ongoing efforts and intervention programs. Assessing the levels and trends in childhood undernutrition by key socioeconomic indicators is instrumental for monitoring the progress of adverse effects on vulnerable groups of the population. Assessing levels and trends in childhood undernutrition also allows program implementers and policymakers to review the population and socioeconomic policies and their implementation per public health perspectives.

Although studies on trends in inequalities in childhood undernutrition are numerous across the world (Vollmer et al., 2017b; Krishna et al., 2018b; Akombi et al., 2019; Angdembe et al., 2019; Fenta et al., 2020; Bekele et al., 2021; Ssentongo et al., 2021; Zegeye, et al., 2021), our knowledge of the trends in Ethiopia is limited due to absence of large-scale studies (Fenta et al., 2020; Bekele et al., 2021; Seboka et al., 2021; Zegeye, et al., 2021). Some of these studies focused on single indicators such as stunting or underweight and were limited in scope and did not examine the socioeconomic factors considering robust statistical methods, including multilevel and decomposition techniques. The previous studies conducted in Ethiopia did not consider the hierarchal nature of data for assessing the factors associated with childhood undernutrition using a multilevel analysis approach to investigate the effects of the individual, household, and community level characteristics. To the best of our knowledge, the studies that investigated the levels and trends in socioeconomic inequalities in childhood undernutrition using multilevel and decomposition techniques are not well documented in Ethiopia. Therefore, the present paper attempted to answer the question "What are the levels and trends of socioeconomic inequalities in childhood undernutrition in Ethiopia over the last two decades?"

5.2. Data and Methods

5.2.1. Study Context

Ethiopia has a diverse topography with different climate variability (NUPI & SIPRI, 2022). Ethiopia's population is predominantly (80 percent) living in rural areas where there are limited opportunities and access to basic services. For instance, only 12 percent of women and 15 percent of men have attended secondary education (USAID, 2019a). Ethiopia is one of the poorest (World Bank, 2020a) and one of the most food insecure (Mohamed, 2017) countries in the world.

The Government of Ethiopia has long been committed to implementing nutrition-focused policies and international commitments to reducing childhood undernutrition. In 1993, Ethiopia endorsed a health policy with priority given to prevent diseases related to undernutrition (Transitional Government of Ethiopia, 1993). Following the recognition of the health policy, the country has developed and implemented four rounds of health sector development programs with special attention to maternal and child health, including child undernutrition from 1998 to 2015 (Ruducha et al., 2017). In 2000, Ethiopia aligned with United Nations member countries to eradicate extreme poverty and hunger as part of the Millennium Development Goals (MDGs) (National Planning Commission, 2015). To ensure equitable access to essential health services, the Health Extension Program (HEP) has been implemented since 2003 in the country (MOH, 2020). To address the chronic food insecurity in drought-prone rural settings of the country, the Productive Safety Net Program has been implemented since 2005 (Devereux et al., 2006) in four phases. Ethiopia has also demonstrated a strong policy commitment to nutrition by developing and implementing the National Nutrition Strategy in 2008, the first National Nutrition Program (2008-2015)(FDRE, 2008), and the second National Nutrition Program (2016-2020) in 2016 and ratified the Seqota declaration to end childhood undernutrition by 2030 (FDRE, 2016). In 2018, the Government of

Ethiopia implemented a Food and Nutrition Policy to attain optimal nutrition status and address childhood undernutrition as well. The Government of Ethiopia is also committed to the Sustainable Development Goals (SDG 2) to end hunger and all forms of malnutrition by 2030. Despite remarkable government commitments to end hunger and improvements made through healthcare delivery system and multisectoral support (Ruducha et al., 2017), over the past two decades, childhood undernutrition remains a major public health concern in the country.

5.2.2. Data Source

This cross-sectional study was based on a representative sample of under-five children drawn from five rounds of the Ethiopian Demographic and Health Surveys (2000-2019). The surveys employed stratified two-stage cluster sampling design for selecting enumeration areas and households within each enumeration area (Central Statistical Agency (CSA) [Ethiopia] and ICF., 2016; Ethiopian Public Health Institute (EPHI) [Ethiopia] and ICF., 2021). Information on socioeconomic, demographic, health, and environmental characteristics of individuals and households was obtained by interviewing women aged 15-49 years. Anthropometry of under-five children was collected in all the five round surveys. Accordingly, we merged data from the five rounds of EDHS (including the 2019 mini-EDHS) and a pooled sample of the five rounds of the EDHS resulted in 48,782 under-five children. We used children recode (KR) datasets that provide data for a wide range of demographic and socioeconomic indicators, including the health and nutrition status of under-five children and their mothers.

5.2.3. Study Variables

The outcome variable of the study was childhood undernutrition. It is measured by the Composite Index of Anthropometric Failure (CIAF) for children under five years of age using the standard anthropometric indicators of stunting, wasting, and underweight to yield a single aggregate figure for all undernourished children (Vollmer et al., 2017b) in Ethiopia in the past two decades. Childhood undernutrition status was categorized as undernourished and coded as 1 if the child had any form of anthropometric failure, and as nourished with an assigned value of 0, if the child had no failure.

The independent variables of this study were grouped as exposure and explanatory variables. Place of residence (community level), household wealth index (household level), and maternal education (individual level) were the three exposure variables identified as key socioeconomic inequality drivers of childhood undernutrition (Geda et al., 2021; Tesema, et al., 2021). The place of residence in EDHS datasets was categorized as rural or urban. In EDHS, children recode has a household wealth index variable for all surveys, except for the 2000 EDHS. For the 2000 EDHS, we constructed a wealth index variable based on household characteristics and assets by applying a principal component analysis (PCA). Observations were classified into five quintiles based on asset index values, and a categorical wealth index (poorest, poorer, medium, richer, and richest) exposure variable was constructed for this analysis. Maternal education was categorized using levels (no formal education, primary, and secondary and above).

Our selection of the explanatory variables was guided by UNICEF's conceptual framework for child malnutrition (UNICEF, 1998, 2013). We regrouped the explanatory variables into community, household, and individual-level variables. The community-level explanatory variables consisted of administrative regions of Ethiopia, and the old eleven administrative regions were recategorized into three regional categories: emerging regions (Afar, Somali, Benishangul-Gumuz, and Gambella), established regions (Amhara; Oromia; Harari; Southern Nations

Nationalities and People's Region (SNNPR); and Tigray) and fully urban (Addis Ababa and Dire Dawa City Administrations) (Bareke et al., 2022).

The household-level explanatory variables included in this study were the sex of the household head (male/female); and household size (<6/6+). The individual-level explanatory variables included in this study were sex of child (male/female); child size at birth as reported subjectively by mothers (small/average/large); birth order ($1^{st}/2^{nd}-4^{th}/5^{+}$); breastfeeding initiation (immediately/lately); duration of breastfeeding (<12/12+months); maternal employment status (yes/no); maternal age at childbirth computed from mother's and her childbirth date (<19/19+); total children ever born(<5/5+); antenatal care visit(<4/4+); place of delivery (home/health facility); and survey period (2000-2011 or 2016-2019).

5.2.4. Statistical Methods

Children with missing anthropometric measures, and other unknown responses were excluded from statistical analysis. Descriptive statistics were used to describe the background characteristics of the study participants. Variance inflation factor(VIF) with a cutoff value of 2.5 (Johnston et al., 2018) and correlation matrix (Senaviratna & Cooray, 2019) were employed to test the multicollinearity effect of the explanatory variables. In this regard, birth order was removed from the model due to strong collinearity with the variable total number of children ($r = 0.8686$) (Senaviratna & Cooray, 2019) and with a VIF value of 5.17 (Johnston et al., 2018).

Bivariate analysis was performed to examine the strength of the association between the explanatory variables and childhood undernutrition. The bivariate analysis was also used to facilitate the decision for inclusion of explanatory variables into multilevel logistic regression analysis.

Multilevel logistic regression analysis was performed using STATA software (StataCorp., 2021) to explore the effect of the explanatory variables on childhood undernutrition. We estimated a three-level model with the individual, household, and community factors as level 1, level 2, and level 3, respectively. The null model was used as a baseline model to determine whether the use of multilevel modeling is appropriate for the analysis or not. Community-level predictors (regional category and place of residence) were included in Model I by controlling household and individual-level variables. Model II was fitted after including household-level predictors in Model I. The final model (Model III) was fitted with community, household, and individual-level explanatory variables to assess the relationship between the exposure variables and childhood undernutrition. Intraclass Correlation Coefficient (ICC), Likelihood Ratio (LR) test and criteria information tests (AIC and BIC) were used to select the best model fitted for multilevel analysis (Luke, 2020).

Concentration Index (CI) was used to measure socioeconomic inequality to quantify the degree of place of residence, household wealth, and maternal education-related inequalities in childhood undernutrition (Pulok et al., 2020). We interacted the survey period with the three exposure variables for trend analysis. Further, to assess trends of key socioeconomic inequalities in childhood undernutrition we employed decomposition rate analysis (Li, 2017; O’Donnell et al., 2007). All statistical analyses were performed using STATA version 17.0 (College Station, Texas 77845 USA).

5.3. Results

5.3.1. Background Characteristics of the Study Participants

Table 5-1 presents the background characteristics of the study participants. About two-thirds of the study participants were surveyed during the 2000-2011 survey period, relative to one-third from 2016-2019. More than half (52.69 %) of children were living in the established regions and nearly 10% of children were from two-chartered city administration (urban regional category). There was a significantly larger proportion of children in rural (82.87%) than (17.13%) in urban areas. Relatively the same proportion (50.61%) of children were living in poor households and non-poor households (49.39%). More than half (55.31%) of children were living in larger households with more than six household members. The descriptive statistics also showed that there were slightly more female children than male children. About 29.30% of children were born from mothers who did not have any formal education, significantly lower than those whose mothers had at least primary-level education (70.70%). Nearly a similar proportion of children had small (30.10%) and large (30.60%) sizes at birth. About 50% of children were breastfed for more than a year while a nonnegligible proportion (5.08%) of children never had breastfed. Breastfeeding was initiated immediately after birth for a considerable proportion (69.53%) of children relative to 30.47% of children lately initiated for breastfeeding. Most (74.87%) of children were born from mothers who had small visits (at most three times) of the health facilities during their pregnancy. A relatively higher proportion (58.88%) of children were born from mothers who gave birth to at most four children than those whose mothers gave birth to at least five children (41.02). About 10% of children were born from young mothers (less than 19 years old). More than half (54.94%) of children were born to unemployed mothers (Table 5-1).

Table 5-1:Background characteristics of the study participants, Ethiopia, 2000-2019.

Variables	**N**	**%**
Survey period		
2000-2011	32388	66.39
2016-2019	16394	33.61
Community level drivers		
Regional Category		
Established	25704	52.69
Emerging	18417	37.75
Urban	4661	9.55
Place of residence		
Rural	40424	82.87
Urban	8358	17.13
Household level driver		
Wealth status		
Poor	24503	50.61
Non-poor	23908	49.39
Household size		
<6	21713	44.51
6+	27069	55.49
Individual level drivers		
Sex of child		
Male	23784	48.76
Female	24998	51.24
Maternal education		
No education	14295	29.30
Primary+	34487	70.70
Child size at birth		
Large	13084	30.60
Average	16802	39.30
Small	12870	30.10
Duration of breastfeeding		
Never breastfed	2464	5.08
< 12 months	22057	45.48
12+ months	23972	49.44
Antenatal care visit		
<4	24403	74.87
4+	8190	25.13
Total children ever born		
<5	28774	58.98
5+	20008	41.02
Age at childbirth		
<19	4933	10.11
19+	43849	89.89
Maternal Employment		
No	23558	54.76
Yes	19464	45.24

Source: Author's analysis using EDHS 2000-2019

5.3.2. Results of Bivariate Analysis

Table 5-2 shows the results of the bivariate analysis for the association between socioeconomic characteristics and childhood undernutrition. Childhood undernutrition was significantly associated (p<0.001) with emerging regions, and rural communities; poor and larger households; mothers who had no formal education and mothers with lesser pregnancy-related antenatal care visits; and children born at home and who had small-size at birth as reported subjectively by mothers. More than half (50.71%) of children were significantly ($p<0.001$) undernourished at the time of the survey (Table 5-2).

Table 5-2: Bivariate analysis of explanatory variables by childhood undernutrition, Ethiopia, 2000-2019.

Explanatory Variables	Childhood Undernutrition				Chi-square
	Nourished		Undernourished		
	N	%	N	%	
Community level drivers					
Regional Category					490.63***
Emerging	8719	45.67	10373	54.33	
Established	6660	50.11	6632	49.89	
Urban	2315	65.88	1199	34.12	
Place of residence					885.14***
Rural	13561	45.70	16116	54.30	
Urban	41133	66.44	2088	33.56	
Household level driver					569.24***
Wealth status					
Poor	7845	43.12	10347	56.88	
Non-poor	9750	55.76	7737	44.24	
Household size					33.48***
<6	7906	51.10	7567	48.90	
6+	9788	47.92	10637	52.08	
Individual level drivers					
Sex of child					25.37***
Male	8948	50.64	8722	49.36	
Female	8746	47.98	9482	52.02	
Place of delivery					922.56***
Home	12499	45.03	15261	54.97	
Health facility	5031	64.48	2771	35.52	
Maternal education					758.75***
No education	11052	44.45	13813	55.55	
Primary+	6642	60.20	4391	39.80	
Child size at birth					309.06***
Large	4869	52.96	4324	47.04	
Average	6050	49.66	6132	50.34	
Small	3789	40.60	5544	59.40	
Duration of breastfeeding					124.02***
Never breastfed	430	52.12	395	47.88	
< 12 months	8859	52.30	8080	47.70	
12+ months	8365	46.41	9661	53.59	
Antenatal care visit					479.87***
<4	8472	46.65	9689	53.35	
4+	4133	62.37	2494	37.63	
Total children ever born					151.02***
<5	11015	51.99	10171	48.01	
5+	6679	45.40	8033	54.60	
Age at childbirth					5.07**
<19	1547	47.41	1716	52.59	
19+	16147	49.48	16488	50.52	
Maternal Employment					43.87***
No	8018	49.75	8098	50.25	
Yes	6770	45.98	7954	54.02	
Survey period					323.61***
2000-2011	10051	45.53	12023	54.47	
2016-2019	7643	55.29	6181	44.71	
Total	**17694**	**49.29**	**18204**	**50.71**	

**** p<.01, ** p<.05, * p<.1*

Source: Author's analysis using EDHS 2000-2019

5.3.3. Results of Multilevel Analysis

Table 5-3 shows the results of the multilevel logistic regression analysis for the determinants of childhood undernutrition. The null model showed statistical significance, suggesting for use of multilevel modeling. Children from the established and urban regions had a statistically ($p<0.001$) lower chance of being undernourished than their counterparts in the emerging regions. Children residing in urban areas were significantly ($p<0.001$) less likely to be undernourished compared to children living in rural areas.

In Model II, children born in established and urban regions, and urban areas had a significantly ($p<0.001$) lower likelihood of being undernourished than those children in the emerging regions and rural areas, respectively. Children living in large households (more than six members) had a significantly ($p<0.05$) higher chance of being undernourished compared to those from smaller households (less than six members). Children from non-poor households had a significantly lower ($p<0.001$) likelihood of undernourishment than their counterparts living in poor households.

In Model III, children from the emerging regions and rural areas had a significantly ($p<0.001$) higher likelihood of being undernourished than their counterparts in the established regions and urban areas, respectively. Children born with small and average size at birth had a significantly ($p<0.001$) higher chance of being undernourished. Maternal education, age at birth, and employment status had significant effects on childhood undernutrition. Children born from uneducated, young (less than 19 years), and unemployed mothers had significantly ($p<0.001$) higher chance of being undernourished than those born from educated, older than 19 years, and employed mothers, respectively. Childhood undernutrition was significantly ($p<0.001$) higher in 2000-2011 compared to the recent survey periods (2016-2019).

From Table 5-3, it was observed that the inclusion of individual level (level 1) explanatory variables into the model slightly decreased the effects of community variation from 0.019 (null model) to 0.011. This indicates the existence of smaller variations between regions and urban-rural areas. Table 3 also shows a reduction in household variation from 0.171 (in Model 0) to 0.159, suggesting that there is relative variation between communities (regions and urban rural areas) in childhood undernutrition.

As seen from Table 5-3, AIC =41676.89 and BIC= 41843.15 of Model III, were the smallest compared to the other models considered. This suggests that the final model fitted well compared to the rest of the models. Further LR test showed statistically significant associations for the fitted multilevel models.

Table 5-3: Multilevel regression modeling (N=30,130), Ethiopia, EDHS 2000-2019

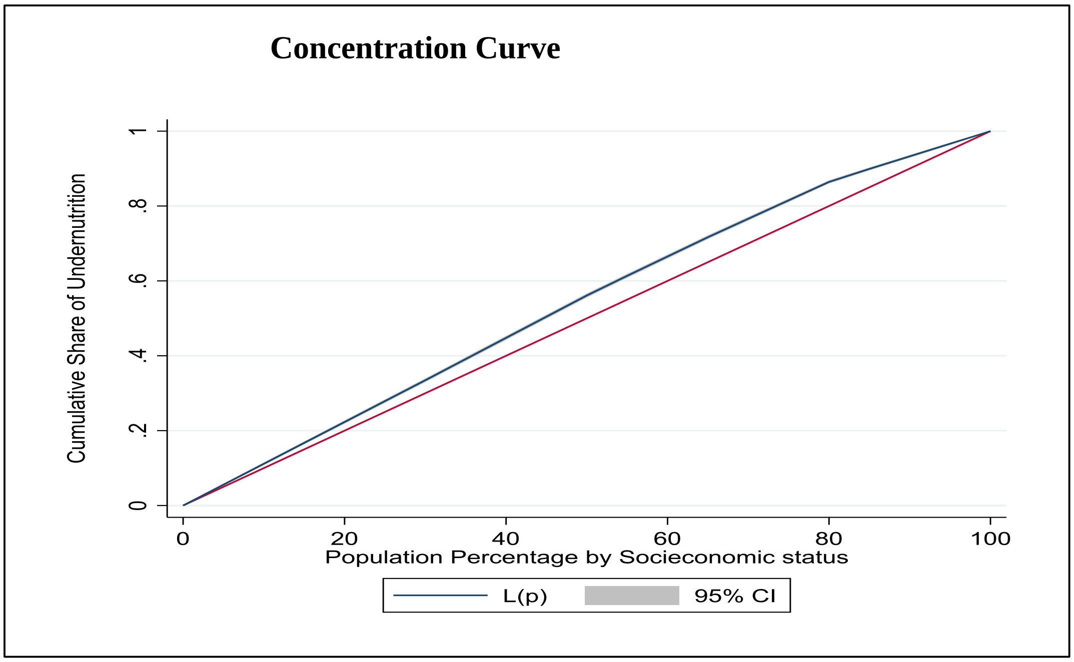
Explanatory variables	**Model 0 Coef. [CI]**	**Model I Coef. [CI]**	**Model II Coef. [CI]**	**Model III Coef. [CI]**
Community-level attributes				
Region: Emerging(ref)				
Established		-.030[-.043, -.017] ***	-.041[-.055, -.028] ***	-.033[-.047, -.020) ***
Urban		-.085[-.109, -0.061] ***	-.086[-.110, -.062] ***	-.081[-.103, -.058] ***
Place of residence: Rural(ref)				
Urban		-.187[-.205, -.168] ***	-.144[-.163, -.124] ***	-.097[-.116, -.079] ***
Household-level attributes				
Household size: (<6) (ref)				
Six and above			.015[.003, .027] **	-.007 [-.021, .006]
Wealth status: Poor (ref)				
Non-poor			-.077[-.09, -.064] ***	-.061[-.074, -.048] ***
Individual-level attributes				
Child Sex: (Male)				
Female				.032[.021,.043] ***
Size at birth: Large(ref)				
Average				.039[.026,.043] ***
Small				.113.099, .127] ***
Duration of breastfeeding: Never(ref)				
Less than 12 months				-.021[-.061, .019]
12 and above months				.045.006 ,085] **
Total children ever born: (<5) (ref)				
Five and above				.027[.013, .041] ***
Education: Primary + (ref)				
No education				.078[.066,.092] ***
Age at first birth (<19)				
19 and above				-.028[-.049, -.008] ***
Maternal Employment: No (ref)				
Yes				.030[.018,.042] ***
Survey period: 2000-2011(ref)				
2016-2019				-.070[-.084, -.058] ***
Constant	.517[.509,.525] ***	0.570[.560, .579] ***	0.608[.590, .626] ***	.491[.442, .540] ***
Random effect				
Community level variance	.005 [.004,.006]	.003[.002,.004]	.003[.002,.004]	0.003[.002,.004]
Household level variance	.038 [.033,.043]	.035[.031,.040]	.034[.030,.40]	0.035[.030,.040]
ICC community	0.019	0.014	0.012	.011
ICC household	0.171	0.158	0.155	.159
AIC	43268.07	42543.88	42405.97	41676.89
BIC	43301.32	42602.07	42489.11	41843.15
LR test (Chi^2)	427.32***	343.9***	326.03***	316.9***

**** p<.01, ** p<.05, * p<.1*

Source: Author's analysis using EDHS 2000-2019

5.3.4. Results of Concentration Index Analysis

Figure 5-1 presents a concentration curve for childhood undernutrition by key socioeconomic status. The concentration curve was displayed above the equality line showing that childhood undernutrition was more concentrated among the lower economic status population group in Ethiopia during the survey period. The concentration index, the area between the equality line and the concentration curve, was -0.141 (p<0.001) which indicates there were inequalities in distribution of childhood undernutrition, and the inequality disfavored the poor in the country (Figure 5-1).



Source: Author's analysis using EDHS 2000-2019

Figure 5-1: Concentration curve of childhood undernutrition, Ethiopia, 2000-2019

Table 5-4 depicts wealth-related childhood undernutrition across place of residence and maternal education. The concentration index estimated from the combined wealth index was statistically significant (CI=-0.14124, p<0.001). Table 5-4 also shows a significant concentration of childhood undernutrition in both rural and urban settings, poor and non-poor households, and uneducated and educated mothers (p<0.001). The point estimates suggest that the level of inequality was greatest in children from rural areas, poor households, and uneducated mothers, but the inequality with children born in urban areas, non-poor households, and educated mothers was relatively small (Table 5-4).

Table 5-4: Socioeconomic inequality in childhood undernutrition by key drivers, Ethiopia, 2000-2019.

Inequality drivers	Concentration Index	Robust std. error	P-value
Household wealth status	-0.14124	0.0096	0.000
Poor	-0.12287	0.0130	0.000
Non-poor	-0.01402	0.0118	0.237
Difference	-0.01088	0.0176	0.000
Place of residence			
Rural	-0.1131	0.0245	0.000
Urban	-0.0876	0.0091	0.000
Difference	-0.0255	0.0262	0.000
Maternal education			
Uneducated	-0.19099	0.0170	0.000
Primary+	-0.06813	0.0064	0.000
Difference	-0.12286	0.0200	0.000

Source: Author's analysis using EDHS 2000-2019

5.3.5. Trends of Socioeconomic Inequalities in Childhood Undernutrition

Table 5-5 shows trend analysis results in childhood undernutrition inequality by exposure variables. The decomposition analysis results revealed that the overall absolute inequality in childhood undernutrition has declined by 9.72 during the period between 2000 and 2019. About 164% of the decline in childhood undernutrition could be attributed to a narrowed gap due to maternal education during the past two decades. However, the widened gap by place of residence and household wealth status contributed to an increase in childhood undernutrition (Table 5-5).

Table 5-5: Trends in socioeconomic inequalities in undernutrition by key drivers in Ethiopia, 2000-2019.

Explanatory Variables	**Survey periods**							
	2000-2005		2000-2011		2000-2016		2000-2019	
	D*	%	D*	%	D*	%	D*	%
Place of residence	-1.14	-46.1	.793	54.3	1.7	-20.60	4.48	-46.2
Household wealth status	5.65	227.5	2.9	49.9	-.085	1.02	1.78	-18.4
Maternal education	-2.02	-81.4	-6.5	34.1	-9.88	119.58	-16.0	164.4
Overall	**2.48**	**100.0**	**-2.8**	**100.0**	**-8.26**	**100.0**	**-9.72**	**100.0**

D*= Absolute difference in the prevalence rate of childhood undernutrition

Source: Author's construction using EDHS 2000-2019

5.4. Discussion

This study investigated the levels and trends of socioeconomic inequality in undernutrition among under-five children in Ethiopia based on representative data from the five national surveys. The study found that regional category, place of residence, household socioeconomic status (wealth index), household size, maternal education, maternal age at birth, maternal employment status, and child size at birth were the most important factors significantly associated with inequalities in childhood undernutrition in Ethiopia during 2000-2019. This finding is consistent with the studies conducted in Ethiopia. This study also showed the existence of key socioeconomic inequalities in childhood undernutrition at individual, household, and community levels (Chikako et al., 2021).

At the individual level, the study indicated that under-five children born from uneducated mothers were at the highest risk of being undernourished, which is consistent with previous studies. This could be due to the well-established reason that educated mothers are better informed about child feeding and healthcare during illness, utilizing health services (Lemessa et al., 2022). Another possible reason could be that educated women are more empowered to make decisions to marry men with higher incomes, live in better communities, and get higher paying jobs which directly or indirectly influence their child’s nutritional status (Kalu & Etim, 2018).

At the household level, the study revealed that children from poor households were at higher risk of being undernourished compared to children from non-poor households. This finding was supported by other studies conducted in Ethiopia (Fenta et al., 2021a; Mohammed et al., 2019; Wondimu & Dejene, 2022). The reason for this might be because poor households could be affected by food insecurity which directly affects the nutritional status of children (World Bank, 2020a). Another possible reason might be that the poor households may not have access to improved water which could affect the children's dietary intake and lead to dehydration that results in childhood undernutrition (Nahalomo et al., 2022). Furthermore, it is worthy to note that undernutrition is a situation that is associated with poverty as it results in hunger and lack of food in the right quantity and quality (Kalu & Etim, 2018).

At a community level, this study showed that under-five children residing in rural areas were at higher risk of being undernourished in the country which is supported by other studies conducted in the country (Bekele et al., 2021; Seboka et al., 2021; Wondimu & Dejene, 2022). This might be due to the reason that children residing in urban areas could have better living conditions and access to food (Fenta et al., 2021a). Besides, most children residing in rural areas may be using unimproved water which leads to unhealthy feeding practices and dehydration resulting in undernutrition (Nahalomo et al., 2022).

A finding of this study pointed out that the level of inequality was highest among children from rural areas, poor households, and uneducated mothers. However, the inequality among children born from urban areas, non-poor households, and educated mothers was minimal. In line with this, our finding showed that childhood undernutrition was more concentrated among lower economic population groups. This might be due to the reason that children residing in urban areas could have better access to health care services and improved water which leads to better feeding practices (Nahalomo et al., 2022). In addition, children residing in poor households might be affected by food insecurity (World Bank, 2020a). Moreover, children from educated mothers may have better access to feeding practice and healthcare, utilizing health services (Lemessa et al., 2022). Furthermore, the wealthiest population groups afford to purchase various quantities and qualities of food to feed their children and get better access to healthcare services (Fenta et al., 2021a).

Another finding of this study is that the overall absolute socioeconomic inequality in childhood undernutrition has declined by 9.72 from 2000 to 2019. The largest proportion of the decline in childhood undernutrition was attributed to a narrowed gap due to maternal education during the past two decades. However, the widened gap by place of residence and household wealth status contributed to an increase in childhood undernutrition. One of the reasons behind such a decline could be the Government of Ethiopia's commitment to implementing the nutritional and health-related policy since 2000. Thus, it is good to encourage continuity of the national nutritional policy commitments and maternal education attainment, and further to set policies that could help address rural-urban and household socioeconomic gaps at national, community, and household levels. Relatively high proportion of the decline in childhood undernutrition could be attributed to a narrowed gap due to the improvement of maternal education during the past two decades in the country. On the other hand, the widened gap due to disparities by place of residence and household asset-based wealth status contributed to an increase in childhood undernutrition. This could be explained by the existing disparities in socioeconomic conditions and access to basic social services such as health care, housing, water, and sanitation services between rural and urban areas, and among the poor and non-poor households; for instance, the higher parasitic infection among poor water and sanitary conditions might increase undernutrition.

The study has both strengths and limitations worth mentioning. The application of rigorous statistical methods and analysis techniques using two-decade nationally representative datasets is the major strength of this study. In addition, the findings of the study were based on a large data set which makes it useful for monitoring of nutrition programs in the country. However, our study did not consider all potential determinants of childhood undernutrition, including household food security status, and maternal nutrition status, among others, that could strongly affect child nutritional status in the country. Although our study claims the association among the studied variables based on repeated retrospective cross-sectional designs applied by EDHSs, we were not able to demonstrate a cause-effect relationship among variables in this study.

5.5. Conclusion

In conclusion, childhood undernutrition was unequal among under-five children in Ethiopia, and largely concentrated among low socioeconomic population groups. The identified key socioeconomic factors of inequality in childhood undernutrition can be used to inform localized interventions and communication strategies to improve the nutritional status of under-five children in Ethiopia. The finding implies the importance of enhancing basic education for women to improve their child feeding practice, utilizing child health care services and child nutritional status. In addition, it is noteworthy to develop communication strategies and nutrition training packages to promote positive health behaviors that are appropriate to improve children's nutritional status at different levels. Moreover, it is crucial to strengthen and support food security and health care programs, including PSNP along with targeted supplementary feeding practices in both rural and urban settings. Furthermore, the study underscores the development of poverty reduction strategies that directly address the existing challenges of food insecurity and childhood undernutrition for the low-income population groups in the country. Finally, the study recommends empowering women with child health knowledge, culturally relevant nutrition education, and strengthened food security programs (like PSNP) with targeted feeding, alongside poverty reduction strategies, to tackle this disparity.

CHAPTER SIX

Trends in Regional Inequalities in Childhood Anemia in Ethiopia: Evidence from the 2005-2016 Ethiopian Demographic and Health Surveys

(The paper was published@ BMC Discover Social Science and Health (2023) 3:7| https://doi.org/10.1007/s44155-023-00038-0), and appears as Shiferaw Tessema Negussie and Regessa Geda Nigatu)

6.1. Introduction

Anemia refers to a lower level of red blood cell or hemoglobin(Hb) than normal (WHO, 2011a), which is one of the key child survival indicators (Nkosi-Gondwe et al., 2021). Anemia affects under-five children disproportionately relative to the general population (Sunguya et al., 2020b). Anemia among children aged 6-59 months is a condition where a child has an insufficient hemoglobin level (<110g/l)(WHO, 2011a), and is one of the most serious public health problems in developing countries (Tesfaye et al., 2020). Childhood anemia leads to poor child growth, impaired cognitive capacity, and learning ability (Zegeye, Ahinkorah, et al., 2021), and causes child morbidity and mortality (WHO, 2011b).

Globally, 269 million children aged 6-59 months were anemic in 2019, of which, 103 million of them were from Africa (Stevens et al., 2022a). Sub-Saharan Africa (SSA) had the highest burden of childhood anemia (Safiri et al., 2021), where more than 64% of under-five children were anemic in 2019 (Tessema et al., 2021). Childhood anemia is still a serious public health concern in SSA countries, including Ethiopia (Seifu & Tessema, 2022). Even though Ethiopia has shown continued commitment to implementing nutrition related programs and policies since 2008 (FDRE, 2008, 2018), childhood anemia remains one of the major public health concerns in the country.

In Ethiopia, the prevalence of childhood anemia largely varies by geographic administration region. For example, the Somali region had the highest level of childhood anemia (83%), followed by the Afar region (75%); whereas the Amhara region had the lowest anemia prevalence among children (42%) in 2016 (Central Statistical Agency (CSA) [Ethiopia] & ICF., 2016). Geographic location-based inequalities in childhood anemia is documented in Ethiopia (Anteneh & Geertruyden, 2021; Endris et al., 2021; Gebreegziabher et al., 2020; Jember et al., 2021). In addition to inequalities by geographic locations, childhood anemia is worsening at the national level, where an unacceptably higher proportion (57%) of children aged 6-59 months were anemic in 2016 compared to the prevalence of 54% in 2005 (Central Statistical Agency (CSA) [Ethiopia] & ICF., 2016). This situation demands evidence-based investigation of trends in inequalities in childhood anemia by administrative regions in the country. Examining trends in regional inequalities in childhood anemia is crucial to monitor the existing programs and consider context-specific interventions at regional levels. In addition, examining trends in regional disparities in childhood anemia helps regional governments and policymakers to review regional policies in line with child health concerns.

Although most previous studies (Mukherjee et al., 2022; Nguyen et al., 2018; Sunguya et al., 2020b; Yang et al., 2018) have focused on the trends in inequalities in childhood anemia, a few studies (Gebreegziabher et al., 2020; Sharaf & Rashad, 2015; Sunguya et al., 2020b) examined regional inequalities in childhood anemia in developing countries. Most of them did not consider the hierarchal nature of data for assessing the factors associated with childhood anemia using a multilevel analysis approach to explore the effects of individual, household, and community characteristics. In addition, none of them quantified the contributions of observed and unobserved heterogeneity at the individual, household, and community levels through decomposition techniques. To the best of our knowledge, no studies were conducted in Ethiopia that examined the trends in regional inequalities in childhood anemia using multilevel and decomposition techniques. This study has thus primarily aimed at filling this knowledge gap, and seeks to answer the question "What is the trend of regional inequalities in childhood anemia in Ethiopia between 2005 and 2016?"

6.2. Data and Methods

6.2.1. Study Setting

Ethiopia is a geographically and ethnically diversified country (Tariku & Gara, 2016). Ethiopia is landlocked and bounded by Eritrea to the north, Djibouti to the east, Somalia to the east and southeast, Kenya to the south, and Sudan and South Sudan to the west (FAO, 2016). Ethiopia has implemented the Millennium Development Goals (MDGs) during the period 2000 to 2015 and registered remarkable achievements in improving child survival. Ethiopia's government is strongly committed and implementing the 2030 Agenda for Sustainable Development and its Sustainable Development Goals (SDGs) as an integral part of its national development framework (National Plan Commission, 2017). The SDG-integrated Growth Transformation Plan (GTP II) was subsequently implemented by all regional states and city administrations (National Plan Commission, 2017). Although Ethiopia's economy had shown increment from 2005 to 2016, there were significant differences in poverty reduction, and non-monetary welfare outcomes across regional states (World Bank, 2020b). Particularly, the pastoral and drought-prone regions (Somali and Afar) are lagging in all non-monetary indicators though regional inequality in consumption is low (World Bank, 2022). Inequality measured by the Gini coefficient, and inequality of opportunity for children largely varies across regional states (World Bank, 2020b).

6.2.2. Data Source

This study was based on the three rounds of the Ethiopian Demographic and Health Surveys (EDHSs) (2005-2016). These nationally representative surveys used cross-sectional study designs to monitor and explore maternal and child health indicators, including anemia. A stratified two-stage cluster sampling design was employed for selecting enumeration areas and households within each enumeration area for EDHSs (Central Statistical Agency (CSA) [Ethiopia] & ICF., 2016). Information on geographic location, socioeconomic, demographic, health, and nutrition-related characteristics of individuals and households was collected from women aged 15-49 years. Accordingly, we merged and included data from the three rounds of EDHS and a pooled sample of 17,766 children aged 6-59 months in the study.

6.2.3. Study Variables

The outcome variable of the study was childhood anemia. The childhood anemia is a dummy variable, and assigned a value of 1 if the child had severe, moderate, or mild anemia level, and 0 if the child is not anemic.

The independent variables of this study were grouped as exposure and explanatory variables. The administrative region (community level) was the exposure variable identified as the key inequality driver of childhood anemia (Gebreegziabher et al., 2020). The old eleven administrative regions of Ethiopia were included in this study and further regrouped into three regional categories for analysis purposes as follows: emerging regions (Afar, Somali, Benishangul-Gumuz, and Gambella), established regions (Amhara, Oromia, Harari, Southern Nations Nationalities, and

People's Region (SNNPR) and Tigray), and fully urban (Addis Ababa and Dire Dawa City Administrations) (Bareke et al., 2022).

The selection of the explanatory variables was guided by UNICEF’s conceptual framework for child malnutrition (UNICEF, 2013) and Mosley and Chen’s child survival framework (Mosley & Chen, 1984). We classified the explanatory variables into the community, household, and individual-level variables. The community-level explanatory variable, place of residence was categorized as rural or urban. The household-level explanatory variables included in this study were the sex of the household head (male/female); household size (<6/6+), number of under-five children in the household (<2/2+), and household wealth index. The household wealth index was classified into five quintiles (poorest, poorer, medium, richer, and richest), and further regrouped into poor (poorest/poorer) and non-poor (medium, richer, and richest).

The individual-level explanatory variables included in this study were sex of child (male/female); child age in months (6-23/24-59 months); child size at birth as reported subjectively by mothers (small/average/large); birth order ($1^{st}/2^{nd}$-$4^{th}/5^{+}$); nutritional status of child (undernourished/nourished); duration of breastfeeding is indexed for each child (never breastfed/ 12 months/ 12+months); maternal education (no formal education, primary, and secondary+); partner’s education (no formal education, primary, and secondary+); maternal employment status (yes/no); mother’s anemia level (anemic/not anemic); maternal age at childbirth computed from mother’s and her childbirth date (<19/19+); place of delivery (home/health facility); and survey period (2005-2011 or 2012-2016).

6.2.4. Statistical Methods

All statistical analyses were performed using STATA version 17.0 (College Station, Texas 77845 USA). Children with missing weight, height/length, and other unknown responses were excluded from statistical analysis. Descriptive statistics were used to describe the background characteristics of the study participants. Variance Inflation Factor (VIF) with a cutoff value of 2.5 (Johnston et al., 2018) was used to test the multicollinearity effect of the explanatory variables and the result is annexed (Annex V). Bivariate analysis was employed to explore the strength of the association between each explanatory variable and childhood anemia. The bivariate analysis was also used to decide for inclusion of explanatory variables ($p<0.2$) into multilevel logistic regression analysis.

Multilevel binary logistic regression analysis was employed using STATA (StataCorp., 2021) to explore the effect of explanatory variables on childhood anemia. Multilevel modeling recognizes the inherent hierarchical structure of the EDHS data, where individuals are nested within the household, and households are nested within the community. For hierarchical data, use of multilevel modeling is demanding as conventional regression analysis provides biased estimates (Snijders & Bosker, 2012). We fitted a three-level models considering the individual, household, and community-level factors. The null model was used as a baseline model to determine whether the use of multilevel modeling was appropriate for the analysis or not. Community-level predictors (administrative regions and place of residence) were included in Model I by controlling household and individual level variables. Model II was fitted after including household-level predictors in Model I. The final model (Model III) was fitted with community, household, and individual-level variables to assess the relationship between the explanatory variables and childhood anemia. Intraclass Correlation Coefficient (ICC), Median Odds Ratio (MOR), Likelihood Ratio (LR) test, and Criteria Information tests (AIC and BIC) were used for select the best model fitted for multilevel analysis (Luke, 2020).

Theil Index was used to measure the inequalities in childhood anemia by administrative regions (Hosseinpoor et al., 2016). The Theil index was decomposed into two components (within a group and between groups) (Wijaya et al., 2021) to explore relative regional inequalities within regions and between regions. The survey period was included to assess trends of regional relative inequalities in childhood anemia (Li, 2017). Furthermore, multivariate decomposition analysis was used to quantify the contributions to group (regional category) inequalities (Powers et al., 2011). All analyses were made using weighted data.

6.3. Results

6.3.1. Background Characteristics of the Study Participants

Table 6-1 describes the background characteristics of the study participants. More than half (54.54 %) of children were living in the established regions, while about 37% of children and more than 8% of children were from emerging regions and two-chartered city administrations (urban regional category), respectively. The majority (84.95%) of children were living in rural areas. A slightly higher proportion of children were living in poor households (50.38%) compared to non-poor households (49.62%). The majority (83.25%) of children were residing in male-headed households compared to those from female-headed households (16.75%). More than half (57.10%) of children were living in a household with more than six household members. About 66% of the respondents had more than two under-five children during the survey period. There was a slightly higher proportion (50.97%) of female children than male children (49.03%). More than 67% of children were 24-59 months of age during the survey period. The majority (81.53%) of children were born at home compared to those born at health facilities (18.47%). A relatively lower proportion (17.92%) of children were at first birth order. A relatively higher proportion (52.51%) of children were undernourished. More than half (57.31%) of children were breastfed for more than a year while a nonnegligible proportion (2.66%) of children never experienced breastfeeding. About 9% of children were born from young mothers (less than 19 years old). A significantly larger proportion (69.65%) of children were born from mothers who did not have any formal education, relative to the smaller proportion (30.35%) of children born from mothers who had at least primary level education. Nearly 53% of children were born from mothers whose partners had no formal education. Most (70.86%) of the children were born from anemic mothers. More than half (57.69%) of children were born to unemployed mothers. About 61% of the study participants were surveyed during the 2005-2011 survey period (Table 6-1).

Table 6-1: Background characteristics of the study participants, Ethiopia, 2005-2016.

Variables (N= 17,766)	**N**	**%**
Community level drivers		
Regional category		
Established	9690	54.54
Emerging	6573	37.00
Urban	1503	8.46
Place of residence		
Rural	15092	84.95
Urban	2674	15.05
Household level factors		
Wealth status		
Poor	8950	50.38
Non-poor	8816	49.62
Sex of household head		
Female	2976	16.75
Male	14790	83,25
Household size		
<6	7622	42.90
6+	10144	57.10
Number of under-five in the HH		
<2	6007	33.81
2+	11759	66.19
Individual level drivers		
Sex of child		
Male	8711	49.03
Female	9055	50.97
Age of child in months		
6-23 months	5790	32.59
24-59 months	11976	67.41

Place of delivery		
Home	14485	81.53
Health facility	3281	18.47
Birth order		
First	3183	17.92
2^{nd} to 4^{th}	7955	44.78
5^{th} and above	6628	37.31
Child size at birth		
Large	5353	30.27
Average	7327	41.43
Small	5007	28.31
Duration of breastfeeding		
Never breastfed	472	2.66
< 12 months	7112	40.03
12+ months	10182	57.31
Nutrition status		
Nourished	8437	47.49
Undernourished*	9329	52.51
Maternal age at childbirth		
<19	1587	8.93
19+	16179	91.07
Maternal education		
No education	12374	69.65
Primary+	5392	30.35
Partner's education		
No education	9301	52.35
Primary+	8465	47.65
Maternal anemia		
Not anemic	12589	70.86
Anemic	5177	29.14
Maternal Employment		
No	10249	57.69
Yes	7517	42.31
Survey period		
2005-2011	10903	61.37
2012-2016	6863	38.63

**Note: Undernourished refers to stunting, wasting, and/or underweight*
Source: Author's analysis using EDHS 2005-2016

6.3.2. Results of Bivariate Analysis

Table 6-2 presents the results of the bivariate association between the hypothesized explanatory variables and childhood anemia. A relatively higher proportion (60.47%) of children were significantly (p<0.001) anemic in the later survey period (2012-2016) compared to the earlier survey period (2005-2011). It is seen that childhood anemia was significantly associated (p<0.001) with regional category, and place of residence at community level. At the household level, household wealth index, sex of household head, the household size, and number of under-five children in the household were significantly (p<0.001) associated with childhood anemia. At the individual level, maternal education, maternal anemia, maternal employment status, partner's education, place of birth, child's nutritional status, age of the child in months, and child size at birth as reported subjectively by mothers were significantly ($p<0.001$) associated with childhood anemia. However, child sex and maternal age at childbirth were not statistically ($p<0.2$) associated with childhood anemia. The overall prevalence of childhood anemia was 54.77% at the national level between 2005 and 2016.

Table 6-2: Bivariate analysis of explanatory variables by childhood anemia, Ethiopia, 2005-2016

Explanatory Variables	Childhood Anemia (N=17,766) Not anemic N	%	Anemic N	%	Chi-square
Community level drivers					
Regional Category					397.31***
Established	5025	51.86	4665	48.14	
Emerging	2374	36.12	4199	63.88	
Urban	636	42.32	867	57.68	
Place of residence					43.01***
Rural	6670	44.20	8422	55.80	
Urban	1365	51.05	1309	48.95	
Household level driver					239.95***
Wealth status					
Poor	3534	39.49	5416	60.51	
Non-poor	4501	51.05	4315	48.95	
Household size					10.78***
<6	3555	4664	4067	53.36	
6+	4480	44.16	5664	55.84	
Number of under-five in the HH					102.17***
<2	3034	50.51	2973	49.49	
2+	5001	42.53	6758	57.47	
Sex of household head					11.48***
Male	6773	45.79	8017	54.21	
Female	1262	42.41	1714	57.59	
Individual level drivers					
Sex of child					0.49
Male	3963	45.49	4748	5451	
Female	4072	44.97	4983	55.03	
Age of child in months					802.10***
6-23 months	1738	30.02	4052	69.98	
24-59 months	6297	52.58	5679	47.42	
Place of delivery					3.79*
Home	6501	44.88	7984	55.12	
Health facility	1534	46.75	1747	53.25	
Nutritional status of child					117.57***
Nourished	4175	49.55	4262	50.45	
Undernourished	3860	60.20	5469	58.60	
Child size at birth					43.80***
Large	2487	46.46	2866	5354	
Average	3442	46.98	3885	53.02	
Small	2067	41.28	2940	58.72	
Birth order					31.09***
First order	1554	48.82	1629	51.18	
2^{nd} to 4^{th} order	3634	45.68	4321	54.32	

Fifth and above	2847	42.95	3781	57.05	
Duration of breastfeeding					324.51***
Never breastfed	217	45.97	255	54.03	
< 12 months	2635	37.05	4477	62.95	
12+ months	5183	50.90	4999	49.10	
Maternal education					52.20***
No education	5376	43.45	6998	56.55	
Primary+	2659	49.31	2733	50.69	
Age at childbirth					0.49
<19	731	46.06	856	53.94	
19+	7304	45.14	8875	54.86	
Partner's education					73.24***
No education	3923	42.18	5378	57.82	
Primary+	4112	48.58	4353	51.42	
Maternal Employment					240.51***
No	4127	40.27	6122	59.73	
Yes	3908	51.99	3609	48.01	
Maternal anemia					418.09***
Not anemic	6310	50.12	6279	49.88	
Anemic	1725	33.32	3452	66.68	
Survey period					146.47***
2005-2011	5322	4881	5581	51.19	
2012-2016	2713	39.53	4150	60.47	
Total	**8035**	**45.23**	**9731**	**54.77**	

**** p<.01, ** p<.05, * p<.1*
Source: Author's analysis using EDHS 2005-2016

6.3.3. Results of Multilevel Regression Analysis

Table 6-3 presents the multilevel logistic regression analysis results for the determinants of childhood anemia. The null model showed statistical significance, indicating that the use of multilevel modeling was appropriate for the analysis. Children from the emerging regions had a statistically (p<0.001) higher chance of being anemic than their counterparts in the established regions. Children residing in urban areas were significantly (p<0.001) less likely to be anemic compared to children living in rural areas (Model I).

Children born in emerging regions, and rural areas had significantly (p<0.001) higher likelihood of being anemic than those children in the established regions and urban areas. Children living in the households (with at least one other under-five child) had a significantly (p<0.001) higher chance of being anemic compared to those from the households (no other child). Children from non-poor households had a significantly lower (p<0.001) likelihood of anemia than their counterparts living in poor households (Model II).

In addition, children from the emerging regions, rural areas, and poor households had significantly (p<0.001) higher likelihood of being anemic than their counterparts in the established regions, urban areas, and non-poor households, respectively. Under-two children (6-23 months of age) were more likely to be anemic than those aged 24-59 months. Children born the fifth and above order had a significantly (p<0.05) higher chance of being anemic compared to those born in the first order. Undernourished (i.e., stunted, wasted, or underweight) children had a significantly (p<0.001) higher chance of being anemic compared to nourished children. Children born from anemic mothers had a significantly (p<0.001) higher chance of being anemic. Similarly, children born to unemployed mothers had a significantly (p<0.001) higher likelihood of being anemic than those born to employed mothers. Childhood anemia was significantly (p<0.001) lower in 2005-2011 compared to 2012-2016. However, household size, sex of household head, place of birth, child size at birth, and maternal and partner's education were not significantly (p<0.05) associated with childhood anemia in multilevel logistic analysis (Model III).

As seen from Table 6-3 below, it was observed that the inclusion of individual level (level 1) explanatory variables into the model decreased the effects of community variation from 0.301 (null model) to 0.001 (Model III). This indicates the presence of substantial variation between regions and rural-urban areas. Similarly, the household variation has also decreased from 0.563 (in Model 0) to 0.029 (Model III), which suggests that there is relative variation between communities (regions and urban-rural areas) and households in childhood anemia.

Moreover, the estimated community level MOR, i.e., the unexplained regional inequality in childhood anemia was also decreased from 1.687 (Model 0) to 1.001(final model) while household level MOR also changed from 2.046 to 1.176. This suggests the existence of variation between communities and households in childhood anemia. The values of AIC and BIC also decreased from 24018.18 and 24041.54 (Model 0) to 22219.29 and 22406.03 (in Model III), respectively. This indicates that the lower values of AIC and BIC are the better model fit of the final model (Model III) as compared to the rest of the models. Furthermore, the likelihood ratio test (LR test) showed statistically significant associations for the fitted multilevel models and indicated a good selection of the models fitted for multilevel analysis.

Table 6-3: Multilevel analysis results of childhood anemia (N=17,766) Ethiopia, EDHS 2005-2016

Explanatory variables	Model 0 Coef. [CI]	Model I Coef. [CI]	Model II Coef. [CI]	Model III Coef. [CI]
Community-level attributes				
Region: Established(ref)				
Emerging		.783[.692, .874] ***	.687[.596, .778] ***	.518[.443, .1593) ***
Urban		.704[.543, .863] ***	.681[.521, .840] ***	.604[.470, .737] ***
Place of residence: Rural(ref)				
Urban		-.564[-.684, -.445] ***	-.315[-.441, -.189] ***	-.180[-.296, -.064] ***
Household-level attributes				
Household head sex: (female) (ref)				
Male			-.027[-.124, .071]	-.059 [-.147, .029]
Household size: (<6) (ref)				
Six and above			.017[-.057, .091]	.017 [-.063, .097]
Number of under-five in HH: (<2) (ref)				
Two and above			.221[.143, .299] ***	.205 [.132, .278] ***
Wealth status: Poor (ref)				
Non-poor			-.364[-.444, -.283] ***	-.253[-.325, -.182] ***
Individual-level attributes				
Place of birth: Home (ref)				
Health facility				-.018[-.123,.086]
Child age in months: (6-23months)				
24-59 months				-1.004[-1.10, -.91] ***
Size at birth: Large(ref)				
Average				-.054[-.130,.022]
Small				.059[.026, .143]
Birth order: First(ref)				
2nd to 4th order				.038[-.054,.133]
5th and above				.114[.002, .226] **
Duration of breastfeeding: Never(ref)				
Less than 12 months				.090[-.120, .299]
12 and above months				-.020[-.219, .180]
Nutritional status: Nourished (ref)				
Undernourished				.411[.345, .477] ***
Maternal education: Primary + (ref)				
No education				.028[-.053,.110]
Partner's education: Primary + (ref)				
No education				.066[-.006,.137] *
Mother's anemia (non-anemic)				
Anemic				.548[.474, .621] ***
Maternal employment: No (ref)				
Yes				-.294[-.359, -.228] ***
Survey period: 2000-2011(ref)				
2012-2016				.337[.267,.406] ***
Constant	.196[.140, .252] ***	-.057[-.121,.007] *	-.002[-.124, .121]	.208[-.054, .471]
Random effect				
Community level variance	.301 [.244,.369]	.221[.176, .277]	.199[.157,.252]	.001[.000,0006]
Household level variance	.563 [.403,.786]	.484[.334,.703]	.467[.318,.684]	.029[.009,.093]
ICC community	0.072	0.055	0.050	0.000
MOR community	1.687	1.565	1.530	1.001
ICC household	0.136	0.121	0.118	0.001
MOR household	2.046	1.942	1.919	1.176
AIC (smaller is better)	24018.18	23666.98	23554.11	22219.29
BIC (smaller is better)	24041.54	23713.69	23631.96	22406.03
LR test (Chi^2)	454.57***	298.34***	260.84***	13.10***

**** p<.01, ** p<.05, * p<.1*

Source: Author's analysis using EDHS 2005-2016

6.3.4. Results of Theil Decomposition Trend Analysis

Table 6-4 shows the results of the Theil decomposition trend analysis. In all, there were increments in the prevalence of childhood anemia between 2005 and 2016 in Afar, Oromia, SNNPR, Harari, Addis Ababa, and Dire Dawa. There was a substantial decrease in childhood anemia between 2005 and 2016 in Tigray, Amhara, Somali, Benishangul, and Gambella. Total relative regional inequality in childhood anemia was highest (0.806) in 2011. The total relative inequality showed a reduction from 0.620 in 2005 to 0.548 in 2016. The overall relative inequalities in childhood anemia could be explained by within-region inequalities, and such inequalities was highest in 2011 (0.806) compared to the year 2005 and 2016. About 98.87%, 97.39%, and 96.90% of the total relative inequalities in childhood anemia could be explained by within-region inequalities, in 2005, 2011, and 2016, respectively. Based on the pooled data, the highest childhood anemia was observed in Somali (78.68%) followed by the Afar region (72.76%) while the lowest childhood anemia was in Amhara (41.01%), Addis Ababa (42.64%) and SNNPR (44%) (Table 6-4).

Table 6-4: Theil decomposition analysis results of anemia (N=17,766), Ethiopia, EDHS 2005-2016

	2005		2011		2016		Pooled (2005-2016)	
Regions	Anemia	Theil's Index	Anemia	Theil's Index	Anemia	Theil's Index	Anemia	Theil's Index
Tigray	56.69	0.564	37.78	0.973	54.11	0.614	47.77	0.739
Afar	60.95	0.495	75.00	0.288	74.97	0.288	72.76	0.318
Amhara	52.22	0.650	35.67	1.031	42.68	0.852	41.01	0.891
Oromia	56.55	0.570	52.29	0.648	66.00	0.416	57.90	0.546
Somali	83.33	0.182	69.52	0.364	83.27	0.183	78..68	0.240
Benishangul	50.73	0.679	46.51	0.766	43.27	0.838	45.75	0.782
SNNPR	45.85	0.780	37.01	0.994	51.12	0.671	44.00	0.821
Gambella	62.23	0.474	50.54	0.682	56.90	0.564	54.29	0.611
Harari	57.49	0.554	55.00	0.598	66.61	0.406	59.20	0.524
Addis Ababa	43.33	0.836	33.14	1.105	49.41	0.705	42.64	0.852
Dire Dawa	62.57	0.469	63.82	0.449	72.37	0.323	67.52	0.393
Total inequality		0.620		0.806		0.548		0.672
Within region inequality		0.613(98.87%)		0.785(97.39%)		0.531(96.90%)		0.656 (97.62%)
Between region inequality		0.008(1.13%)		0.021(2.61%)		0.018(3.10%)		0.016 (2.38%)

Source: Authors analysis using EDHS 2005-2016.

6.3.5. Results of Multivariate Decomposition Analysis

Table 6-5 illustrates the overall and detailed multivariable decomposition analysis of regional inequalities in childhood anemia between 2005 and 2016. The result revealed that 47.12% of observed regional inequalities in childhood anemia can be attributed to the differences in characteristic effects (explained) while 52.88% could be due to the differences in coefficient effect (unexplained component). Addressing the household socioeconomic status, maternal anemia, and maternal employment status gaps would be expected to reduce the inequalities in childhood anemia among the emerging and non-emerging regions by about 12.91%, 13.83%, and 14.15%, respectively. However, keeping the existing gaps in household socioeconomic status, and maternal employment status could significantly ($p<0.01$) contribute to widening the regional inequalities in childhood anemia by about 25.34%, and 23.64%, respectively (Table 6-5).

Table 6-5: Multivariable decomposition of emerging and non-emerging regions in anemia, EDHS 2005-2016

Childhood Anemia	Coef.	se	z statistic	p-value	[95% CI]	Percent
Overall						
Characteristics gap (E)	0.094	0.008	12.56	0.000	[0.079, 0.108]	47.12
Coefficients gap (C)	0.105	0.011	9.58	0.000	[0.084, 0.127]	52.88
Overall gap	0.199	0.010	21.63	0.000	[0.181, 0.217]	100.0
Due to Difference in Characteristics (E)						
Place of residence	-0.0002	0.002	-0.11	0.912	[-.004, 0.004]	-0.11
Socioeconomic status	0.026	0.004	6.28	0.000	[0.018, 0.033]	12.91
Number under-five in HH	0.006	0.002	2.72	0.007	[0.002, 0.010]	2.88
Child age in months	-0.003	0.0003	-10.71	0.000	[-.0035, -.0024]	-1.48
Birth order	0.001	0.001	1.27	0.205	[-.0004,0.002]	0.34
Undernutrition	0.0001	0.00002	3.91	0.000	[0.0001, 0.036]	0.36
Partner's education	0.010	0.001	2.92	0.003	[0.003,0.015]	4.56
Maternal anemia	0.028	0.004	6.68	0.000	[0.019, 0.036]	13.83
Maternal employment	0.028	0.004	7.44	0.000	[0.021 0.036]	14.15
Due to Difference in Coefficients (C)						
Place of residence	0.004	0.003	1,37	0.171	[-.002, 0.011]	2.23
Socioeconomic status	-0.050	0.013	-3.96	0.000	[-.075, -.025]	-25.34
Number under-five in HH	0.032	0.037	0.86	0.390	[-.040, 0.103]	15.82
Child age in months	0.057	0.039	1.47	0.141	[-.019, 0.133]	28.73
Birth order	0.015	0.032	0.48	0.633	[-.048,0.079]	7.77
Undernutrition	-0.011	0.011	-0.97	0331	[-.033, 0.011]	-5.44
Partner's education	0.032	0.011	3.07	0.002	[0.012,0.053]	16.24
Maternal anemia	-0.003	0.005	-0.67	0.505	[-.013, 0.007]	-1.72
Maternal employment	-0.047	0.010	-4.74	0.000	[-.067, -.028]	-23.64
_cons	0.076	0.061	1,24	0.214	[-.044, 0.196]	38.23

6.4. Discussion

The present study employed multilevel, Theil index, and multivariate decomposition analyses to examine trends in regional inequalities in childhood anemia in Ethiopia using three rounds of nationally representative data (2005-2016). The weighted prevalence of childhood anemia computed from the three rounds of pooled data analysis was 54.77%, higher than the prevalence of childhood anemia in Uganda (50%) (Nankinga et al., 2019) and lower than in Nigeria (68.1%) (Obasohan et al., 2022), which needs attention to address contributing factors in the country.

Our multilevel analysis shows that the community, household, and individual level factors had significant contributions to the observed childhood anemia prevalence in the country. This finding is consistent with previous studies conducted in Ethiopia (Gebreegziabher et al., 2020) and Sub-Saharan African countries (Amegbor et al., 2022). Children living in emerging regions and rural areas had a significantly higher likelihood of childhood anemia compared to children from established regions and urban settings, which is consistent with a previous study in Ethiopia (Heinrichs et al., 2021). The likely reason could be due to differences in socioeconomic status, access to resources, level of education, and cultural feeding practices (Gebreegziabher et al., 2020). In addition, individuals living in urban areas might have access to better education, awareness of child health and risk of anemia, income, and resources compared to rural areas that are directly or indirectly related to poverty (Gebreegziabher et al., 2020).

At the household level, household socioeconomic status (wealth index) was significantly associated with childhood anemia. Consequently, our finding witnessed that children from poor households were more likely to be anemic than those living in non-poor households. This could be directly linked with nutritional intake as anemia is a nutritional disease, and the richer households have the economic means to meet their children's nutritional and health needs (Amegbor et al., 2022). In line with this finding, undernourished (stunted, wasted, or underweight) children were more likely to be anemic compared to nourished children. This could be due to the fact that anemia is one of nutritional diseases which is associated with poor dietary habits (Amegbor et al., 2022). Children born to employed mothers were less likely to be anemic compared to those born from unemployed mothers. This might be due to the reason that employed mothers can have relatively better chance to buy additional nutritious food for their children compared to unemployed mothers. In our analysis, children born from anemic mothers were more likely to be anemic as compared to those born from non-anemic mothers. One possible explanation might be that maternal iron deficiency could have potential effects on childhood anemia (Shukla et al., 2019).

Our finding from the Theil index analysis indicated a reduction of about 13.14% in the relative regional inequality in childhood anemia from 0.620 in 2005 to 0.548 in 2016. This could be due to the continued implementation of national and international commitments, including Millennium Development Goals (MDGs), Health Extension Program (HEP), Child survival strategies and Nutrition Programs as well as Seqota declaration and Growth Transformation Plans in all regions. In this study, the overall relative inequalities in childhood anemia were largely explained by within region inequalities. The Theil index analysis using pooled data showed that the highest childhood anemia in Somali (78.68%) followed by the Afar region (72.76%) while the lowest childhood anemia was in Amhara (41.01%) from the pooled. This indicates that the existence of the highest burden of childhood anemia in emerging regions as compared to non-emerging regions (i.e., established regions and urban regions). The potential reason could be the fact that Somali and Afar regions are drought and malaria-prone regions and lagging on all non-monetary (World Bank, 2022), and the drought and malaria could directly or indirectly escalate the prevalence of childhood anemia in these regions.

Our multivariate decomposition analysis also revealed that more than half (52.88%) of the regional inequalities in childhood anemia was due to difference in unobserved characteristics (coefficient effect), and the remaining (47.12%) was due to differences in observed characteristic effects. Household socioeconomic status (wealth index), maternal anemia and maternal employment have significantly explained the variations in the regional inequalities in childhood anemia between emerging and non-emerging regions over the study period. Therefore, leveling the socioeconomic status, maternal employment status and maternal anemia could have contributed to reduce the emerging and non-emerging regional inequalities in childhood anemia by about 12.91%, 13.83% and 14.15%, respectively. This suggests due attention to addressing the existing disparities in socioeconomic status, maternal anemia and maternal employment status between emerging and non-emerging regions to reduce the regional inequality in childhood anemia.

Finally, it is worth mentioning the strengths and limitations of the present study. Concerning the strength of the study, our findings were based on a nationally representative sample of respondents from all regions that could be generalized to the broader population in Ethiopia. Thus, the findings could be helpful in addressing regional differences in the prevalence of anemia among children. However, we also recognized that this study has some limitations. First, this study is based on repeated cross-section surveys, which was not possible to draw a cause-effect relationship. Second, all the DHS data are self-reported, and hence, they might be influenced by recall bias. In addition, most mothers are illiterate which could lead to non-response, omission, and commission errors. Third, as the present study focused on well-documented determinants of childhood anemia, there might be potential factors not included in the analysis, including food security, appropriate dietary feeding, and others. Lastly, macro-level factors affecting anemia (such as policy, finance, government commitment, and others) were not captured in this analysis.

6.5. Conclusion

With only a 13.14% reduction in the relative regional inequalities in childhood anemia over 11 years, progress made in Ethiopia was very slow. Overall, two-thirds of the change in regional inequalities in childhood anemia was due to unexplained or unobserved behavioral responses (coefficient effect). Household wealth index, antenatal care visit, and maternal employment status significantly contributed to reduce and increase in regional inequalities in childhood anemia over the study period. Therefore, the present study underscores the importance of addressing the socioeconomic status, antenatal visit, and maternal employment status of the emerging regions to the non-emerging levels further to reduce inequality in childhood anemia between the emerging and non-emerging regions. There is also a need for the implementation of multidimensional and multisectoral approaches which could help reduce the regional inequalities in childhood anemia.

CHAPTER SEVEN

Residential Inequalities in Child Mortality in Ethiopia: Multilevel and Decomposition Analyses

(The paper was published @ International Journal of Population Studies: *IJPS* 2021, 7(2), 47–59 https://doi.org/10.36922/ijps.v7i2.392, and appeared as Negussie S.T. Chalachew G.D, Nigatu R.G., & Terefe D.B)

7.1. Background

Inequality in child mortality is a global priority. Socioeconomic inequality in child mortality has been a concern of the United Nations since the adoption of the World Population Plan of Action in 1974 and its implementation agreed upon at the International Conference on Population in 1984 (United Nations, 1991). The 1984 International Conference on Population strongly urged all governments, regardless of the mortality levels of their population to reduce mortality levels and socioeconomic and geographical differentials in their countries and to improve health among all population groups, especially among those groups where the mortality levels are the highest (United Nations Department of International Economic and Social Affairs, 1985). Moreover, the United Nations set a Millennium Development Goal (MDG4) to reduce the child mortality rate by two-thirds between 1990 and 2015 (UNICEF, 2015). Although MDG4 was targeted to reduce the under-five mortality rate (U5MR) by 67%, the target was not achieved but reduced by 53% globally (United Nations Inter-agency Group for Child Mortality Estimation (UN IGME), 2020) from 91 deaths per 1000 in 1990 to 43 deaths per 1000 in 2015 (UNDP, 2016). Apart from the low reduction, there are inequalities across regions and countries.

Due to different efforts exerted by governments and development partners, the number of under-five deaths dropped from 12.5 million in 1990 to 5.2 million in 2019 globally. As a result, 14,000 children died before age 5 every day in 2019 compared to 34,000 in 1990 and 27,000 in 2000 (United Nations Inter-agency Group for Child Mortality Estimation (UN IGME), 2020). Even the

2019 figure can be considered substantial in light of the Sustainable Development Goal (SDG) targets and efforts to eliminate preventable child deaths between birth and age five. In this regard, the SDG aims to reduce the under-five mortality rate to at least as low as 25 deaths per 1000 live births by 2030 (UN, 2016). However, Sub-Saharan Africa (SSA) remains the region with the highest under-five mortality rate in the world (United Nations Inter-agency Group for Child Mortality Estimation (UN IGME), 2020). In 2019, the region had an average under-five mortality rate of 76 deaths per 1,000 live births, which was 20 times higher than that of the region of Australia and New Zealand (United Nations Inter-agency Group for Child Mortality Estimation (UN IGME), 2020). Moreover, the SSA countries had high child mortality rates with significant urban-rural differences (Yaya et al., 2019).

Ethiopia is one of the Sub-Saharan African countries with a high burden of childhood mortality, ranking third in Africa (Dheresa et al., 2022). Ethiopia was among the five countries which accounted for half of the global under-five deaths in 2019 (United Nations Inter-agency Group for Child Mortality Estimation (UN IGME), 2020). Child mortality declined by 76 % from 96 deaths per 1000 live children in 1990 to 23 per 1000 live children in 2015 (Yohannes et al., 2017). Ethiopia had significant inequalities in child mortality between rural and urban areas where the risk of child mortality is higher in rural than urban areas (Gebresilassie et al., 2021). The overwhelming urban-rural inequality in child mortality can be explained by individual, household, and community-level factors. The different approaches employed by various governments may make community-level factors influence under-five mortality differently. Therefore, this study attempts to answer the research question "*What are the key factors that explain the rural-urban, intra-rural, and intra-urban gaps in child mortality in Ethiopia?*" Answering this question is instrumental in explaining the inequalities in child mortality between and within urban-rural areas.

Thus, the objective of this paper was to examine the key factors that explain both between and within rural-urban inequalities in child mortality in Ethiopia.

7.2. Conceptual Framework

This study is based on the two conceptual frameworks formulated (Mosley & Chen, 2003; 1984; Schultz, 1984) to identify determinant factors and their relationships to child survival. Schultz (1984) is one of the researchers who developed the conceptual framework for child survival. Schultz's conceptual framework focused on the structural relationship between child survival and the individual's behavioral variables along with both observed socioeconomic (like, social, economic, community, and religious) and biomedical (breastfeeding patterns and hygiene), and unobserved biological factors. In Schultz's framework, biomedical factors are modeled as having a direct effect on child mortality, while socioeconomic factors affect child survival indirectly as they work through the biomedical factors (Schultz, 1984). Likewise, Mosley and Chen (1984) classified the determinants of child survival as socioeconomic (such as social, economic, community and regional determinants) and biomedical factors (such as maternal, environmental, nutrition, injuries and personal illness). In Mosley and Chen's framework, socioeconomic factors are proposed to indirectly affect child survival as they pass through the proximate factors while proximate determinants affect child mortality directly (Mosley & Chen, 2003). Mosley and Chen categorized a set of proximate determinants into maternal factors (age, birth order and birth intervals); environmental hygiene factors (source of water and type of sanitation); nutrient deficiency (calories, protein and micro nutrient deficiency); injury (related to physical, burn and poisoning injury); and personal illness control (immunization, bed net, etc.). In addition, Mosley and Chen also classified the socioeconomic determinants of child survival into individual, household, and community-level variables (Mosley & Chen, 2003; 1984).

Several studies have applied hierarchical models that are rooted in Mosely and Chen (1984) to analyze how micro (i.e., individual and household level) and macro/contextual (community-level) factors influence childhood mortality at different levels. For example, in South Asia, Zakaria et al. (2019) examined the effects of socio-economic, demographic, and environmental variables on child mortality, and found that urbanization reduces child mortality. In South-Central Asia, Dendup et al. (2020) investigated the factors associated with childhood mortality in rural and urban Bhutan and the roles of the factors in explaining childhood mortality disparities using the 2012 National Health Survey. Logistic regression was applied to investigate the determinants, and the analysis revealed that children of younger mothers, born in households without safe sanitation and electricity had increased odds of childhood mortality in the rural areas of the country. The larger number of births and household sizes are associated with an increased odds of mortality irrespective of rural-urban residence (Dendup et al., 2020).

In Bangladesh, Rahman & Alam (2021) examined the role of socioeconomic indicators on child mortality and found that urbanization had a positive effect on child mortality; whereas maternal education hurt the child mortality rate. Noor & Uddin (2021) also found out that the mother's education, higher birth order, and size of the child at birth had a significant effect on child mortality in Bangladesh. Jayathilaka et al. (2021) explored socioeconomic and demographic factors associated with childhood mortality in Sri Lanka, and the improved source of drinking water had a lower risk of child mortality.

In Ghana, maternal age, mother’s education, household wealth index, place of delivery, and birth order are found to be the most significant socioeconomic determinants that influence child mortality in rural-urban Ghana (Sarkodie, 2021).

In Ethiopia, Zewudie et al. (2020) examined determinants of childhood mortality and found that place of residence, mother's educational level, religion, breastfeeding status, sex of the child, birth order, and household size were found to be significant predictors of childhood mortality. Likewise, Fenta and Fenta (2020) in their study examined that individual-level factors, including maternal educational background and age of the mother at first birth are associated with a small number of child deaths. On the other hand, a higher birth order is associated with a higher number of child deaths (Fenta & Fenta, 2020).

More specifically, a few recent studies explored factors that determine childhood mortality including rural-urban inequalities (Adeyinka et al., 2020; Dendup et al., 2020; Gebresilassie et al., 2021; Yaya et al., 2019). In Sub-Saharan Africa, Yaya et al. (2019) examined the rural-urban gap in childhood mortality using the Demographic and Health Survey (DHS) in 35 SSA countries. The data were analyzed using Oaxaca-Blinder decomposition to depict the urban-rural gap in the factors of under-five mortality. The results of the decomposition analysis revealed that the urban-rural differentials were due to demographic, socioeconomic, and proximate factors. Yaya et al. (2019) also explored that very young age at first birth, children of higher birth order and those with small size at birth had a higher risk of childhood mortality. Children from the richest households and births from educated women had a lower risk of under-five mortality. Maternal age, maternal education, wealth index, total children ever born, and size of the child at birth have contributed towards explaining urban-rural gap in childhood mortality (Yaya et al., 2019). In Nigeria, a study conducted by Adeyinka et al. (2020) highlighted children residing in different communities are likely to have different mortality risks. The study employed a multilevel multinomial logistic regression analysis method to identify the social determinants of age-specific childhood mortalities and to estimate the within-and between-community variations of mortality among under-five children. The multilevel analysis revealed that maternal education, and household wealth index accounted for high variation in childhood mortalities across communities (Adeyinka et al., 2020).

Despite the widely acknowledged rural-urban differential in childhood mortality, not all urban or rural populations are homogenous. Living in socioeconomically disadvantaged urban areas might be associated with increased childhood mortality risks, as living in resource-rich and environmentally healthy rural areas might be associated with a lower risk of childhood mortality. In this regard, a few studies documented intra-urban differentials in child mortality in developing countries (Antai & Moradi, 2010; Touré et al., 2020; Das, 2021). For example, a study in Nigeria found that living in socioeconomically disadvantaged urban areas was independently associated with the risk of child death even after controlling for individual child and mother-level demographic and socioeconomic characteristics (Antai & Moradi, 2010). A study in Ghana also examined intra-urban spatial variation in childhood mortality rates and pointed out that nontraditional toilet types and water supply sources were associated with high rates of under-five mortality rates (Touré et al., 2020). In India, Das (2021) showed that poverty, low female literacy, and unsafe delivery in the community are associated with a higher risk of child mortality in urban areas. The economic inequalities in child mortality are higher in the urban poor than in rural but inequality is widened in the urban poor in India (Das, 2021).

In Ethiopia, Gebresilassie et al. (2021) examined the factors behind the rural-urban differentials in under-five mortality in Ethiopia using Fairlie's decomposition technique to analyze data from three round Ethiopian Demographic and Health Surveys. The child size at birth, mother's education, and household size contributed to narrowing the disparity in child mortality rate (Gebresilassie et al., 2021).

To sum up, although the previous studies (Yaya et al., 2019; Dendup et al., 2020; Ekholuenetale et al., 2020), including the study conducted in Ethiopia (Gebresilassie et al., 2021) have examined the rural-urban inequalities in child mortality risks, the determinants contributing to intra-rural and intra-urban inequalities in child mortality were not covered. On the other hand, a few studies (Antai & Moradi, 2010; Touré et al., 2020; Das, 2021) assessed only intra-urban differentials in child mortality in developing countries. However, the determinants contributing to intra-rural and intra-urban inequalities in child mortality have not been previously well documented in Ethiopia. Therefore, this paper seeks to contribute evidence on the major factors explaining the rural-urban inequalities in child mortality, including the intra-rural and intra-urban gap in Ethiopia.

7.3. Data and Methods

This section highlights the data source, study variables, and statistical methods used for the present study. Study context, design, and data source are presented under data source subsection. Description of study variables is presented under the study variable subsection while the overall data diagnosis and analysis techniques are discussed in the statistical methods subsection.

7.3.1. Data Source

We used data from the 2016 Ethiopia Demographic and Health Survey (EDHS) which was collected from January 18, 2016 to June 27, 2016 (Central Statistical Agency (CSA) [Ethiopia] &

ICF., 2016). The 2016 EDHS is a large-scale and cross-sectional survey conducted in a nationally representative sample of households from all regions of Ethiopia. The EDHS 2016 data was collected based on a two-stage stratified cluster sampling technique. In the first stage, 645 clusters (202 urban and 443 rural) were selected. In the second stage, a fixed number of 28 households per cluster were selected to gather the socioeconomic and health status of children below the age of five and their mothers' reproductive ages (15-49 years). The 2016 EDHS used standardized questionnaires to collect detailed information on birth histories, health, nutrition, and related information on mothers and children. Accordingly, a total of 10,641 under-five children born during the last five years preceding the survey date were included in the children's database. Of these, data for 8162 children (12-59 months of age) were extracted from the children's dataset for this study.

7.3.2. Study Variables

The outcome variable of the present study was the risk of child mortality. It was measured in EDHS as the probability of dying between the exact age of one and the fifth birthday, and assigned a value of 1 if the child died between 12 and 59 months, and 0 if the child was alive at least until the age of 59 months. To explore the effects of individual, household, and community-level characteristics on child mortality and to examine their influences and relationships between rural-urban effects, the explanatory variables were grouped into individual, household, and community-level factors.

The **individual-level** factors included in this paper are sex of the child; child size at birth as reported subjectively by mothers; breastfeeding initiation; birth order; place of delivery; maternal education; maternal age at first birth; number of children ever born; and mother's religion.

The **household-level** factors comprise of the sex of the household head; household size; source of drinking water; type of toilet facility; type of cooking fuel; and combined wealth status. In the 2016 EDHS dataset, the urban/rural asset scores are standardized to a standard normal distribution with a mean of zero and a standard deviation of one. Finally, the standardized urban/rural wealth index scores of the poorest, poorer, middle, richer, and richest levels are further regrouped into poor and non-poor for the analysis of intra-urban and intra-rural inequalities in child mortality.

The **community-level** factors consist of administrative regions and place of residence (urban vs rural). For the sake of simplicity, the eleven administrative regions of Ethiopia were categorized into three regional categories: emerging regions (Afar, Somali, Benishangul-Gumuz, and Gambella), established regions (Amhara, Oromia, Harari, Southern Nations Nationalities, and People's Region (SNNPR) and Tigray) and fully urban (Addis Ababa and Dire Dawa City Administrations). Here, it is good to note that the emerging regions are drought-affected areas, pastoralists, and marginalized in terms of basic infrastructure as well as least developed as compared to established and urban regional categories (Bareke et al., 2022). Moreover, to analyze the child mortality inequality gaps between and within rural-urban areas, the place of residence was assigned as a dummy variable.

7.3.3. Statistical Methods

We used STATA version 15.1 for statistical data processing and analysis. We have checked missing values and there were no missing values for the outcome variable, but children with unknown birthplaces, and children from not de-jure residents were excluded from the analysis, which accounted for 3.2% of the cases. In this study, de jure residents refer to those residents who are usually living in a definite area, and who were counted as the resident of the area. We used a correlation matrix to test the multicollinearity effect of the explanatory variables using a cut-off of 0.6 known to cause concern in multicollinearity (Senaviratna & Cooray, 2019). Due to strong collinearity with a place of residence (r = 0.8077) and sex of household head (r = 0.6236), the variable total children ever born was removed from the model. Place of residence cannot be removed since it is the key identifier in investigating residential inequality in child mortality. After the removal of the total number of children ever born, an absolute correlation coefficient of less than 0.6 was observed among predictors indicating the absence of multicollinearity. Although the variable 'total children ever born' was removed from the model, the birth order was included in the model to explore the relative effects of fertility on child mortality.

Considering the hierarchical nature of the 2016 EDHS dataset into account, we used a multilevel (i.e., three levels: community, household, and individual level) analysis technique to get unbiased estimates of standard errors and enable the modeling of between-level interactions by treating every effect at the appropriate level. A multilevel modeling explicitly accounts for the clustering of the units of analysis. Besides, the multilevel modeling provides a unified treatment for effects at individual, household, and community levels. Since the outcome variable is binary, a multilevel logistic regression (Balluerka et al., 2010; Gelman & Hill, 2010) was used as a standard model for assessing the effect of socioeconomic and contextual factors on child mortality in this study. Accordingly, four models were fitted, including a null model. The null model was fitted to determine whether the use of multilevel modeling was appropriate in the analysis. Further, all models were checked through interclass correlation (ICC) and criteria information tests (AIC and BIC), and their values were used to select the best model fitted for multilevel analysis. We used the Likelihood Ratio (LR) test to test the statistically significant differences between the two models based on the ratio of their likelihoods.

We also used decomposition analysis to quantify the contribution of observed and unobserved heterogeneity at the individual, household, and community levels. The decomposition analysis helps understand variance estimates whether regressors are random or fixed, which is based on multiplying regression coefficients using regressors. Hence, to explain the urban-rural, intra-urban, and intra-rural inequalities in child mortality, we used the Blinder-Oaxaca decomposition technique for a non-linear variable. This technique allows for quantifying the gap between the advantaged and the disadvantaged groups (Fairlie, 2005; Jann, 2008; Sinning et al., 2008; Romaric & Susuman, 2015; Yaya et al., 2019; Ameyaw et al., 2021).

7.4. Results

7.4.1. Background Characteristics of the Study Participants

Table 7-1 shows the background characteristics of the study population. About 45.5% of children were born to mothers residing in emerging regions and almost the same proportion was born to mothers in established regions, and 81.8% of children were born in rural areas. The majority (78.56%) of respondent women were from male-headed households; 83.09% of children were born to households that had unimproved sanitation facilities; only 5.28% of children were born to households that had clean cooking fuel and 55.49% of households had six or more members. Table 7-1 also depicts that more than half (54.8%) of children were born to households grouped with poor wealth status; 45.5% of children were born to households that had improved sources of drinking water. Most (70.7%) children were born at home; a slightly higher proportion (52.1%) of children were female. Table 7-1 also illustrates that 19.7%, 43.9%, and 36.4% of children were born in the first, the 2^{nd} -4^{th} birth order, and 5^{th} and above birth order, respectively. More than 80% of mothers had initiated breastfeeding with their kids immediately after birth. About 6% of mothers had given birth before entering the age of 18 years. More than 66 % of children were born to uneducated mothers. Nearly 29% of children were born to mothers of Orthodox religion, and 51.2% were born to mothers of Muslim religion followers (Table 7-1).

Table 7-1: Background characteristics of study participants in Ethiopia, 2016.

Variable (N=8162)	Category	N	%
	Emerging	3703	45.47
Regional Category	Established	3706	45.41
	Urban	753	9.23
Place of residence	Rural	6680	81.8
	Urban	1482	18.2
Sex of household head	Male	6412	78.56
	Female	1750	21.44
Household size	Less than 6	3633	44.51
	6+	4529	55.49
Combined wealth status	Poor	4473	54.8
	Non-poor	3689	45.2
Source of drinking water	Improved	3550	45.5
	Unimproved	4612	56.5
Type of sanitation facility	Unimproved	6782	83.09
	Improved	1380	16.91
Type of cooking fuel	Solid fuel	7731	94.72
	Clean fuel	431	5.28
Place of birth	Home	5770	70.7
	Health facility	2392	29.3
Sex of child	Male	3910	47.9
	Female	4252	52.1
Breastfeeding initiation (N=6911)	Delayed	1331	19.26.
	Immediately	5580	80.74
	Large	2592	31.8
Size of a child at birth	Average	3403	41.7
	Small	2167	26.5
	First	1609	19.7
Birth Order	2-4	3579	43.9
	5th and above	2974	36.4
Age at childbirth	Less than 18	459	5.62
	18 and Above	7703	94.38
Maternal education	No education	5399	66.2
	Primary+	2763	33.8
Total children ever born	1-4	4665	57.16
	5 and above	3497	42.84
	Orthodox	2342	28.7
Religion	Muslim	4181	51.2
	Others	1639	20.1

Source: Author's analysis using EDHS 2016

7.4.2. Results of Multilevel Analysis

Table 7-2 depicts results from the multilevel regression analysis. Here, it is crucial to understand that all individual and household level factors are nested within the community (place of residence), hence it needs to explain the residential inequalities using multilevel analysis. With this understanding, four multilevel models were fitted using only variables with a p-value < 0.2 (Heinze & Dunkler, 2017) from the bivariate analysis (not presented in this paper). The overall multilevel analysis was conducted with a random intercept (only) model for both community and household levels. Firstly, the null model (Model 0, i.e., a model without explanatory variables) was fitted and showed statistically significant variation in child mortality across individual and household levels by place of residence justifying the applicability of multilevel models for analysis.

Secondly, Model I was fitted after including community-level predictors in the null model. Significant mortality differentials were observed by place of residence and regional category in Model I. Statistically significant (p<0.001) lower risks of death were found among children born in the urban areas relative to children in the rural areas. Children from the emerging regions had higher risks of death compared to their counterparts in the established regions of the country.

Thirdly, Model II was fitted after including household-level predictors in Model I. Similar to Model I, children born in urban areas had statistically significant (p<001) lower risks of death than those children in rural areas. Children living in the emerging regions had statistically significant (p<001) higher risks of death as compared to their counterparts in the established regions of the country. Children living within small household size (less than six members) had a significantly (p<001) lower risk of death as compared to those from households of large size (six and above members). Children from households with improved sanitation facilities had significantly lower ($p<0.001$) risk of death than their counterparts living in households with unimproved sanitation facilities.

Finally, the full model (Model III) with all proposed explanatory variables including community-level predictors was fitted to examine the effect of residential location on child mortality. Significant mortality differentials were observed at community-, household- and individual-level attributes. In Model III, we found that children from the emerging regions had higher risks of death compared with their counterparts in the established regions of the country. Similarly, the lower risks of death were found among children born in the urban areas as compared with children in the rural areas as observed in Models I and II. As we found in Model II, children from small household size (less than six members) had a significantly ($p<001$) lower risk of death as compared to those from households of large size (six and above members). Likewise, children from households with improved sanitation facilities had significantly lower ($p<0.001$) risk of death than their counterparts living in households with unimproved sanitation facilities. Children born with large and medium size at birth had a significantly ($p<0.001$) lower risk of death as compared to small size at birth. This study also revealed that children born at health facilities had a lower risk of death as compared to their counterparts born at home. Children born to Orthodox Christian follower mothers had a significantly lower risk of death than children born from Muslim mothers ($p<0.05$). In this study, maternal education, maternal age at birth, and wealth status had no statistically significant difference to explain child mortality inequality by place of residence (Table 7-2).

Table 7-2: Binary Mixed-effects Multilevel Regression Model (N=8162), EDHS 2016

Attributes	Model 0	Model I	Model II	Model III
	Coef. [CI]	Coef. [CI]	Coef. [CI]	Coef. [CI]
Constant	-3.015[-0.60, -2.43] ***	-2.84[-3.001, -2.0681] ***	-3.081[-3.30, -2.87] ***	-2.457[-2.94, -1.97] ***
Community-level attributes				
Place of residence (Rural)				
Urban		-0.883[-1.216, -0.549] ***	-0.768[-0.045, -0.006] ***	-0.543[-0.929, -0.156] ***
Region: Emerging(ref)				
Established		0.4261[0.237,0.615] ***	0.472[0.272,0.672] ***	0.3381[0.112,0.565) ***
Urban		0.230[-0.188,0.649]	0.353[-0.074,0.780]	0.329[-0.110,0.769]
Household-level attributes				
Household size (<6) (ref)				
Six and above			0.482[0.301, 0.663] ***	0.853[0.622, 1.083] ***
Type of sanitation(unimproved)				
Improved			-0.535[-0.894, -0.175] ***	-0.498[-0.857, -0.139] ***
Wealth status: Poor (ref)				
Non-poor			0.0616[-0.150,0.272]	0.008[-0.051, 0.390]
Individual-level attributes				
Child Sex: (Male)				
Female				0.2515[0.068,0.434] ***
Birth weight: (Small)				
Large				-0.168[-0.402,0.064]
Average				-0.232[-0.452, -0.015] **
Birth Order (5th & above)				
First				-0.626[-0.96, -0.29] ***
2nd -4th				-0.624[-0.866, -0.382] ***
Place of birth: Home(ref.)				
Health facility				-0.195[-0.452, 0.063]
Religion: Muslim(ref)				
Orthodox				-0.346[-0.613, -0.079] **
Others				-0.048[-0.297,0.200]
Education: No edu. (ref)				
Primary +				-0.121[-0.358,0.114]
Age at first birth (<18+)				
18 and above				-0.269[-0.655,0.117]
Random effect				
Community level variance	.161 [0.020,01.334]	$9.74e^{-36}$	$4.21e^{-35}$	$3.58e^{-35}$
Household level variance	.104 [0.025,0,434]	0.111[0.028,432]	0.101[0.023,0.444]	0.102[0.023,0.455]
ICC	0.074	0.033	0.030	0.30
AIC	3857.55	3833.27	3801.94	3766.10
BIC	3878.57	3868.31	3857.99	3829.21
LR test (chi2)	-	28.27***	37,34***	55.86***

**** p<.01, ** p<.05, * p<.1*
Source: Author's analysis using EDHS 2016

7.4.3. Results of Decomposition Analysis

The multilevel analysis has provided evidence for the existence of a statistically significant higher risk of child death in rural areas as compared to those living in urban areas in Ethiopia. However, the rural-urban residential gap and the intra-rural and intra-urban gaps are not known yet. For this purpose, the present study employed Blinder-Oaxaca decomposition analysis based on the place of residence and urban/rural wealth status, separately. Table 7-3 presents the decomposition of the rural-urban inequalities in child mortality grouped by place of residence. The rural-urban decomposition analysis showed the mean predictions by groups and their difference. For the sake of understanding, we converted mean prediction into proportion per 1000. The decomposition result showed that the mean proportion of child deaths was 71 deaths per 1000 children for rural and 32 deaths per 1000 children for urban areas, resulting in a rural-urban differential of 39 deaths per 1000 children. There would be 39 deaths per 1000 children change in rural areas when applying the urban areas coefficient and characteristics to rural areas' behavior/characteristics. In the rural-urban decomposition analysis, child size at birth, birth order, type of sanitation facilities, and wealth status contributed to explaining the rural-urban gap in child mortality. On the other hand, child sex, religion, household size, and regional categories contributed to widening the child mortality gap.

Table 7-3: Blinder-Oaxaca decomposition of rural-urban in risk of child death, EDHS 2016

Blinder-Oaxaca decomposition				**Number of obs. = 8,162**		
				Model = logit		
Group 1: Rural				**N of obs. 1 = 6680**		
Group 2: Urban				**N of obs. 2 = 1482**		
CD	Coef.	Std.Err.	z statistic	p-value	[95%Conf.	Interval]
Overall						
Rural	0.071	0.003	22.750	0.000	0.065	0.077
Urban	0.032	0.005	7.080	0.000	0.023	0.041
Difference	0.039	0.006	6.970	0.000	0.028	0.049
Explained	0.017	0.060	0.280	0.777	-0.100	0.134
Unexplained	0.022	0.060	0.360	0.716	-0.095	0.139
Explained						
Child sex	-0.000	0.000	-0.750	0.451	-0.000	0.000
Child size	0.008	0.007	1.110	0.267	-0.006	0.022
Birth order	0.047	0.034	1.380	0.167	-0.020	0.114
Religion	-0.009	0.009	-1.010	0.314	-0.027	0.009
Household size	-0.032	0.022	-1.460	0.144	-0.074	0.011
Toilet type	0.027	0.038	0.700	0.481	-0.048	0.101
Wealth status	0.018	0.051	0.350	0.725	-0.081	0.117
Regional cat.	-0.042	0.029	-1.430	0.154	-0.099	0.016
Unexplained						
Child sex	0.000	0.005	0.100	0.923	-0.010	0.011
Birth weight	0.019	0.041	0.460	0.644	-0.061	0.098
Birth order	0.027	0.060	0.460	0.646	-0.090	0.145
Religion	-0.020	0.044	-0.460	0.646	-0.106	0.066
Household size	-0.033	0.072	-0.450	0.652	-0.174	0.109
Toilet type	0.001	0.015	0.090	0.927	-0.027	0.030
Wealth status	-0.015	0.023	-0.680	0.495	-0.060	0.029
Regional cat.	0.019	0.051	0.370	0.709	-0.081	0.119
_cons	0.023	0.047	0.490	0.627	-0.070	0.115

Source: Author's analysis using EDHS 2016

Table 7-4 depicts the decomposition of the intra-rural inequalities in child death grouped by rural wealth status. The intra-rural decomposition analysis revealed that the mean proportion of child death was 76 and 64 deaths per 1000 children for rural poor and rural non-poor, respectively. As a result, there would be 12 deaths per 1000 children change in rural poor when applying the rural non-poor coefficient and characteristics to rural poor characteristics. The intra-rural decomposition analysis revealed that child size at birth, and regional category contributed to explaining the intra-rural gap in child mortality. On the other hand, child sex, religion, household size, and type of sanitation facilities contributed to widening the intra-rural child mortality disparity.

Table 7-4: Blinder-Oaxaca decomposition of intra-rural in risk of child death, EDHS 2016

Blinder-Oaxaca decomposition			Number of obs = 6,680			
			Model = logit			
Group 1: Rural Poor = 0			N of obs 1 = 4045			
Group 2: Rural Non-poor = 1			N of obs 2 = 2635			
CD	Coef.	Std.Err.	z statistic	p-value	[95%Conf.	Interval]
Overall						
Rural Poor	0.076	0.004	18.330	0.000	0.068	0.084
Rural Non-poor	0.064	0.005	13.500	0.000	0.054	0.073
Difference	0.012	0.006	1.900	0.058	-0.000	0.024
Explained	0.013	0.009	1.360	0.175	-0.006	0.031
Unexplained	-0.001	0.010	-0.080	0.939	-0.021	0.020
Explained						
Child sex	-0.000	0.000	-0.580	0.562	-0.000	0.000
Child size	0.001	0.002	0.390	0.699	-0.003	0.005
Birth order	0.000	0.001	0.640	0.521	-0.001	0.001
Religion	-0.001	0.001	-0.720	0.473	-0.003	0.001
Household size	-0.001	0.001	-2.160	0.031	-0.002	-0.000
Toilet type	-0.002	0.003	-0.830	0.405	-0.007	0.003
Regional cat.	0.016	0.008	2.000	0.045	0.000	0.031
Unexplained						
Child sex	-0.301	115.735	0.000	0.998	-227.138	226.535
Birth weight	-0.117	44.892	0.000	0.998	-88.103	87.870
Birth order	-0.685	263.195	0.000	0.998	-516.537	515.167
Religion	-0.550	211.166	0.000	0.998	-414.427	413.327
Household size	-0.056	21.473	0.000	0.998	-42.143	42.030
Toilet type	0.202	77.716	0.000	0.998	-152.118	152.523
Regional cat.	0.429	164.569	0.000	0.998	-322.121	322.979
_cons	1.077	414.172	0.000	0.998	-810.685	812.840

Source: Author's analysis using EDHS 2016

Table 7-5 presents the decomposition result of the intra-urban inequalities in child mortality grouped by urban wealth status. The intra-urban decomposition illustrated the mean proportion of urban child death by poverty difference. On average, there would be 47 deaths per 1000 children for urban poor and 21 deaths per 1000 children for urban non-poor, resulting in 26 deaths per 1000 children change in urban poor when applying the urban non-poor coefficient and characteristics to urban poor behavior. In intra-urban decomposition analysis, birth order, and type of sanitation facilities contributed to widening the intra-urban gap in child mortality. On the other hand, household size and regional categories contributed to explaining the intra-urban child mortality gap.

Table 7-5: Blinder-Oaxaca decomposition of intra-urban in risk of child death, EDHS 2016

Blinder-Oaxaca decomposition — Number of obs. = 1,482; Model = logit

Group 1: Urban Poor = 0 — N of obs. 1 = 643

Group 2: Urban Non-poor = 1 — N of obs. 2 = 839

CD	Coef.	Std.Err.	z statistic	p-value	[95%Conf.	Interval]
Overall						
Urban Poor	0.047	0.008	5.640	0.000	0.030	0.063
Urban Non-poor	0.021	0.005	4.330	0.000	0.012	0.031
Difference	0.026	0.010	2.620	0.009	0.006	0.044
Explained	-0.082	0.074	-1.110	0.266	-0.227	0.063
Unexplained	0.107	0.077	1.390	0.164	-0.044	0.258
Explained						
Child sex	-0.003	0.003	-1.190	0.235	-0.008	0.002
Child size	-0.000	0.000	-0.010	0.990	-0.001	0.001
Birth order	-0.060	0.034	-1.770	0.077	-0.126	0.006
Religion	-0.007	0.030	-0.240	0.813	-0.067	0.052
Household size	0.019	0.016	1.230	0.218	-0.011	0.050
Toilet type	-0.041	0.048	-0.840	0.400	-0.135	0.054
Regional cat.	0.009	0.034	0.260	0.792	-0.057	0.075
Unexplained						
Child sex	-0.031	0.022	-1.420	0.154	-0.074	0.012
Birth weight	0.018	0.047	0.380	0.707	-0.075	0.110
Birth order	-0.070	0.051	-1.380	0.169	-0.169	0.030
Religion	-0.028	0.033	-0.840	0.399	-0.093	0.037
Household size	0.078	0.060	1.300	0.192	-0.039	0.195
Toilet type	0.059	0.059	1.000	0.317	-0.056	0.174
Regional cat.	-0.049	0.073	-0.660	0.507	-0.193	0.095
_cons	0.130	0.125	1.040	0.298	-0.115	0.376

Source: Author's analysis using EDHS 2016

7.5. Discussion

To the best of our knowledge, this is the first paper that examined residential inequalities in child mortality taking intra-urban and intra-rural inequalities into account in Ethiopia. We employed multilevel and decomposition analyses techniques to explore the key factors that widen the rural-urban, intra-rural, and intra-urban gaps in child mortality in the country. We found statistically significant higher child mortality in rural areas than in urban areas which is also consistent with the previous studies (Adeyinka et al., 2020; Dendup et al., 2020; Gebresilassie et al., 2021; Yaya et al., 2019). This might be due to differences in access and distance to public health services, population living standards, health conditions, child health care-seeking behavior, and exposure to media by place of residence in Ethiopia.

Our findings also provided confirmatory evidence that the largest part of the rural-urban inequality in child mortality was attributable to individual, household, and community level factors. At the individual level, the child's size at birth, and birth order contributed to explaining the rural-urban gap in child mortality similar to other studies (Gebresilassie et al., 2021; Yaya et al., 2019). This could be due to the relatively high prevalence of home delivery in rural settings where the child size at birth may not be recorded. Another potential reason might be due to the high prevalence of early marriage in rural areas which could lead to teenage delivery with a lower physical preparedness for pregnancy, and difference in access to public health services including family planning, ante-natal care, childhood immunization and health education services provided in rural and urban areas of Ethiopia.

At the household level, the household wealth status and type of sanitation facilities were found to be the key factors in explaining rural-urban inequality in child mortality in line with the previous studies (Dendup et al., 2020; Touré et al., 2020). This could be due to the child mortality in urban areas could be influenced by relatively higher education attainment and income as compared to rural settings in the country.

At a community level, our analysis revealed significant mortality inequalities by regional category and place of residence. Children from the emerging regions (Afar, Somali, Benishangul-Gumuz, and Gambella) had higher risks of death compared to children in the established regions (Amhara, Oromia, Harari, Southern Nations Nationalities, and People's Region (SNNPR) and Tigray) of the country (Gebresilassie et al., 2021). This might be due to the reason that the emerging regions are drought-affected areas, pastoralists, and marginalized in terms of basic infrastructure development with high prevalence of infectious diseases such as malaria and differences in health service coverages (Bareke et al., 2022).

Moreover, this study revealed that child size at birth, birth order, and regional category by wealth status are key factors in explaining intra-rural inequalities in child mortality. This might be due to the differences in socioeconomic status of the poor and non-poor rural residents, where the rich (non-poor) could have access to improved water and sanitation facilities that affect the risk of child mortality in Ethiopia. This study also found that the intra-urban inequality in child mortality was explained by household and community-level factors. For example, the household size was found to explain intra-urban inequalities in child mortality by wealth status. This might be linked to having larger household sizes may reduce access to childhood nutrition status within poor urban households as compared to non-poor, which in turn affects child survival in Ethiopia. Regional category by wealth status was another contributing factor in explaining intra-urban inequality in child mortality in this study. One of the potential reasons for this could be the existence of urban slums with environmentally and economically poor dwellers in emerging and established regions as well as urban regional categories, including Addis Ababa, the capital of Ethiopia. Thus, the present paper suggests that substantial efforts to reduce residential inequalities in child mortality shall focus more on the child's birth size, birth order, sanitation facility, and socioeconomic status of different population subgroups of the country.

The present paper is not free from any limitations. For example, we focused on well-known and extensively reported determinants of child mortality in the literature, whereas others such as childhood nutrition status (including exclusive breastfeeding for the first six months and appropriate complementary feeding), as well as the households' affordability and accessibility to care and the food insecurity and distance to the nearest health facilities remain unexplored. In this regard, the necessity of assessing the factors related to the intra-urban and intra-rural disparity in child mortality may not be well explained. Hence, the author agree that the present work may represent just an early attempt at a much more integrated investigation of the determinants of child mortality in Ethiopia. We prospect that further similar studies will be conducted as the complex relations among the factors concurring in child mortality for the intra-urban and intra-rural disparities in Ethiopia are not yet fully understood.

7.6. Conclusion

This study attempted to answer the research question that inquires what are the key factors that explain both between and within rural-urban inequalities in child mortality. The findings suggest that there is statistically significant residential inequality in child mortality in rural than urban settings. The findings also showed that some residential inequalities in child mortality occur at a level that could be addressed by targeting children, and households, and some occur at a community level that could be addressed by targeting place of residence and regions. Following findings of decomposition analysis, critical multifaceted regionally specific interventions are suggested to be a potentially better approach for addressing the intra-rural and intra-urban differential in child mortality with policies tailored to the disadvantageous specific condition in emerging regions, i.e., Afar, Somali, Benishangul-Gumuz, and Gambella. Furthermore, the present paper suggests that substantial efforts to reduce intra-urban inequalities in child mortality should focus more on household size. Finally, the importance of the finding, if taken into cognizance and extended to cover the entire country will not only reduce inequality in child mortality but will bring the country close to achieving SDG targets by 2030.

CHAPTER EIGHT

Trends in Maternal Education-based Inequalities in Under-five Mortality in Ethiopia: Multilevel, Decomposition and Concentration Index Analyses

(Manuscript submitted for publication @ *Discover Social Science, and; authors are Negussie Shiferaw and Nigatu Regassa*)

8.1. Background

Under-five mortality is a global public health concern with its burden remains enormous, where globally five million children died before reaching the age of five years in 2021 alone (UNSD, 2022). Under-five mortality rate (U5MR) is a key indicator for child survival (Mosley & Chen, 1984) and the Sustainable Development Goal (SDG)(UN, 2022). UN urges countries to improve child survival with a target of U5MR to reduce to 25 per 1000 live children and reduce inequality within and among countries by 2030 (UN, 2016). In this regard, although substantial global progress has been made in reducing the under-five mortality rate (U5MR) by 60% from 12.6 million in 1990 to 5.0 million in 2021, children born in Sub-Saharan African (SSA) countries are subject to the highest risk of childhood death in the world (United Nations Inter-agency Group for Child Mortality Estimation (UN IGME), 2023). Ethiopia, one of the SSA countries, is home to a high burden of under-five mortality in Africa (third) and globally (tenth) (Dheresa et al., 2022).

Achieving the SDG-3 targets in reducing U5MR requires understanding and monitoring of changes in inequalities in under-five mortality by key determinants. Particularly, understanding how maternal education could reduce under-five mortality is paramount to addressing the inequalities in under-five mortality. Maternal education represents one of the key drivers of inequality in child health and reduces 31% of under-five mortality (Balaj et al., 2021). Maternal education also increases maternal awareness about child health and hygiene, thereby reducing the U5MRs in SSA countries (Bado & Susuman, 2016). In Ethiopia, U5MR is largely varied by maternal education status ranging from 19 deaths per 1000 children to 70 deaths per 1000 children between children born from mothers who had more than secondary education and mothers with no education (EPHI & ICF, 2021). In this regard, it is crucial to examine trends in maternal education-based inequalities in under-five mortality in countries like Ethiopia where literacy level is unacceptably low.

Although some previous studies were conducted on maternal education-based inequalities in under-five mortality in the context of developing countries (Bado & Susuman, 2016; Balaj et al., 2021; Okoli et al., 2022; Wuneh et al., 2022) maternal education-based inequalities, none of them explored overtime changes in inequalities in under-five mortality. Even the few available studies (Sreeramareddy et al., 2013; Sastry, 2020; Agbadi et al., 2021) on trends in inequality in under-five mortality in developing countries did not consider effects at individual, household, and community levels. Moreover, little efforts were made to quantify the contribution of observed and unobserved heterogeneity of maternal education status through decomposition analysis.

Recent studies in Ethiopia (Wolde & Bacha, 2022; Yalew et al., 2022) conducted trends and correlates on under-five mortality, but they did not assess inequality issues. To the best of our knowledge, there is no study conducted in Ethiopia that examined the trends in maternal education-based inequalities in under-five mortality using multilevel and decomposition techniques. To fill a gap, the present study seeks to answer the question "What is the level and extent of trends in maternal education-based inequalities in under-five mortality in Ethiopia between 2000 and 2016?" Attempting to answer this question, the present study aimed to examine trends in inequalities in under-five mortality by maternal education in Ethiopia using multilevel, multivariate decomposition, concentration index, and decomposition rate analyses.

8.2. Conceptual Framework of the Study

The conceptual framework of the present study was based on the two predominant conceptual frameworks (Mosley & Chen, 1984; Schultz, 1984). Mosely and Chen's conceptual framework was used to understand the analytical relationship between determinants and child survival, and classifications of the determinants of child survival. Mosely and Chen (1984) classified determinants as socioeconomic (i.e., social, economic, community, and religious variables) and biomedical (which includes: maternal, environmental, nutrition, and child health-related determinants) factors. Schultz's conceptual framework is also used to understand the structural relationship between child survival and the individual's behavioral variables, including socioeconomic and biomedical determinants. In Schultz's framework, the determinants were classified into observed socioeconomic (such as social, economic, community, and religious), biomedical (breastfeeding patterns and hygiene), and unobserved biological factors (Schultz, 1984). Mosley and Chen categorized a set of proximate determinants into maternal factors (age, birth order, and birth intervals); environmental hygiene factors (source of water and type of sanitation); nutrient deficiency (calories, protein, and micronutrient deficiency); injury (related to physical, burn, and poisoning injury); and personal illness control (immunization, bed net, etc.) (Mosley & Chen, 1984). In Mosley and Chen's framework, socioeconomic factors are proposed to indirectly affect child survival as they pass through the proximate factors while proximate determinants affect child mortality directly (Mosley & Chen, 1984). In Schultz's framework, biomedical factors are also modeled to have a direct effect on under-five mortality, while socioeconomic factors affect child survival indirectly as they work through the biomedical factors (Schultz, 1984). Furthermore, Mosley and Chen also classified the determinants of child survival into individual-, household-, and community-level variables (Mosley & Chen, 1984).

8.3. Data and Methods

8.3.1. Study Setting

Ethiopia is one of the oldest countries in the world (Mohajan, 2013) and the second most populous country in Africa, next to Nigeria, with estimated 122 million people in 2022 (Department of Economic and Social Affairs, 2022). Ethiopia has achieved the Millennium Development Goal (MDG-4) with a target of 67% reduction in under-five mortality, and shown strong commitment in implementing the 2030 Agenda for Sustainable Development to attain Sustainable Development Goals (SDG3) targets (National Plan Commission, 2017). However, the reduction of under-five mortality has not been advanced as expected to exert a tremendous effort to achieve the SDG-3 target (Dheresa et al., 2022).

8.3.2. Study Design and Data Sources

The present study used the Ethiopian Demographic and Health Surveys (EDHSs) which are repeated cross-sectional surveys conducted in four rounds (from 2000 to 2016). All EDHSs employed stratified two-stage cluster sampling design for selecting enumeration areas and households within each enumeration area for EDHSs (Central Statistical Agency (CSA) [Ethiopia] & ICF., 2016). The EDHSs collected information about geographic location, and socioeconomic, including maternal education; demographic, health, and nutrition-related characteristics of individuals and households from women aged 15-49 years. The datasets were downloaded from the DHS website based on secured and approved online permission. This study used children's files that contain information about socioeconomic, demographic, and geographic characteristics of under-five children, their parents, households as well as their communities from pooled/merged data. The outcome and explanatory variables were extracted from the pooled data consisting of 35,404 under-five children used for the analysis.

8.3.3. Study Variables

The overall selection of the study variables was guided by the two conceptual frameworks(Mosley & Chen, 1984; Schultz, 1984) discussed above. Accordingly, the study variables were classified into two major groups: outcome and explanatory variables. The outcome variable was under-five mortality, which was assigned a value of 1 if the child died between 0 and 59 months and 0 if the child was alive at least until the age of 59 months. We also classified the explanatory variables into the community, household, and individual-level variables.

Maternal education (individual level) was the key inequality driver of under-five mortality (Balaj et al., 2021; Wuneh et al., 2022) as discussed in Chapter Four above, and categorized into no formal education, primary, secondary and above, and regrouped into no education and some educated (primary, and secondary and above) for assessing inequalities in under-five mortality.

The community-level explanatory variables were administrative regions and place of residence. The old eleven administrative regions of Ethiopia were included in this study and further regrouped into three regional categories for analysis purposes as follows: emerging regions (Afar, Somali, Benishangul-Gumuz, and Gambella), established regions (Amhara, Oromia, Harari, Southern Nations Nationalities, and People's Region (SNNPR) and Tigray) and fully urban (Addis Ababa and Dire Dawa City Administrations) (Bareke et al., 2022). Place of residence was also categorized as rural or urban.

The household-level explanatory variables included in this study were the sex of household head (male/female); household size (<6/6+); household asset-based wealth index; source of drinking water (improved/unimproved); type of toilet facility (improved/unimproved); and type of cooking fuel (solid/clean). The category of the household source of drinking water, type of toilet facility, and type of cooking fuel was based on the DHS guide (Croft et al, 2018). The household asset-based wealth index was classified into five quintiles (poorest, poorer, medium, richer and richest) in all EDHS but the 2000 EDHS (we computed using Principal Component Analysis technique), and, we regrouped into poor (poorest/poorer) and non-poor (medium, richer and richest) for multilevel and decomposition analysis.

The individual-level explanatory variables were sex of the child (male/female); child age in months (0-11/12-36/37-59 months); place of delivery (home/health facility); child size at birth as subjectively reported by mothers (small/average/large); birth order ($1^{st}/2^{nd}-4^{th}/5^{+}$); duration of breastfeeding is indexed for each child (never breastfed/ breastfed for <12 months/12 + months); partner's education (no formal education/primary+); maternal education (no formal education/primary+); total children ever born(<5/5+); maternal employment status (yes/no); maternal age at childbirth computed from mother's and her childbirth date (<19/19+); and survey period (2000-2005 or 2011-2016).

8.3.4. Statistical methods

Although there were no missing values for the outcome variable, children with missing and unknown responses for the source of drinking water, type of sanitation facility, type of cooking fuel, place of delivery, duration of breastfeeding, and size at birth (which accounts for less than 3%) were excluded from statistical analysis. We used the Variance Inflation Factor (VIF) with a cutoff value of 2.5 (Johnston et al., 2018) to test the multicollinearity effect of the explanatory variables, and birth order was removed from model due to high collinearity with VIF value of 3.62 which was greater than 2.5 (Johnston et al., 2018). After the removal of birth order, the value of VIF for each explanatory variable was less than 2.5 with a mean VIF value of 1.32 indicating the absence of a multicollinearity effect among explanatory variables (Annex VI). Even though the birth order was removed from modeling, the total number of children ever born was included to assess the relative effect of fertility on under-five mortality.

Descriptive statistics were used to describe the background characteristics of the study participants. Bivariate analysis was used to examine the strength of the association between each explanatory variable and under-five mortality to decide for inclusion of significant explanatory variables ($p<0.2$) into multilevel logistic regression analysis. The multilevel modeling was employed due to the hierarchical nature of the EDHS data, where individuals are nested within households, and households are also nested within community/cluster/enumeration areas. For such data, applying multilevel modeling is crucial to minimize biased estimates resulting from conventional regression analysis (Snijders and Bosker, 2012). Multilevel binary logistic regression analysis (StataCorp., 2021) was used to examine the net effects of each explanatory variable on under-five mortality. Apart from the null model, three-level models were fitted considering the individual, household, and community level factors. The null model was fitted to identify whether the use of multilevel modeling is appropriate for the analysis or not. Community-level predictors (administrative regions and place of residence) were included in Model I by controlling household and individual-level variables. Model II was fitted after including household-level predictors in Model I. The final model (Model III) was fitted with community, household, and individual-level explanatory variables to assess the association between the explanatory variables and under-five mortality.

Furthermore, we used the Intraclass Correlation Coefficient (ICC), Median Odds Ratio (MOR), Likelihood Ratio (LR) test, and Criteria Information tests (AIC and BIC) to select the best model fitted for the multilevel analysis (Luke, 2020).

Multivariate decomposition analysis was used to quantify the contributions of group (regional category) inequalities (Powers et al., 2011). Concentration index was used to quantify the degree of maternal education-based inequalities in under-five mortality (Pulok et al., 2020). Furthermore, we used the survey period to assess trends in maternal education-based inequalities in under-five mortality for decomposition rate (Li, 2017; O'Donnell et al., 2007). All analyses were made using weighted data using STATA version 17.0 (College Station, Texas 77845 USA).

8.4. Results

8.4.1. Background Characteristics of the Study Participants

Table 8-1 depicts the background characteristics of the study participants. There were slightly higher proportion (51.19%) of female children than male children (48.81%). Relatively higher proportion (39.17%) of children were born with average size at birth as subjectively reported by their mothers. More than 85% of children were born at home. Nearly the same proportion (44.5%) of children were 12-36 and 37-59 months of age during the survey time. More than 54% of children were breastfed for more than a year while nearly 5% of children were not provided breastfeeding. More than half (57%) of children were born from mothers whose partners had no formal education. Larger proportion (74.35%) of children were born from mothers who did not have any formal education compared to children born from mothers who had at least primary level education (25.65%). Most (90.06%) of the children were born from mothers whose age was 19 years and above, while nearly 10% of children were born from young mothers (< 19 years old). About 55%

of children were born from unemployed mothers. Slightly lower proportion (48%) of the study participants were surveyed during 2000 - 2005 survey period.

At household level, slightly the largest (31%) and the smallest (13.65%) proportions of children were living in the poorest and middle households, respectively. More than half (55.09%) of children were living in households with more than six household members. The majority (84.24%) of children were from male headed households compared to those living in female headed households (15.76%). About 64%, 86% and 96% of children were living in households which were dependent on unimproved source of drinking water, unimproved sanitation facility and solid cooking fuel during the survey period, respectively. At the community level, about 56 % and 36% of children were living in the established and emerging regions, respectively. The majority (85%) of children were living in rural areas (Table 8-1).

Table 8-1: Background characteristics of the study participants, Ethiopia, 2000-2019

Variables (N= 35,404)	**N**	**%**
Individual level drivers		
Sex of child		
Male	17282	48.81
Female	18122	51.19
Place of delivery		
Home	30185	85.26
Health facility	5219	14.74
Child size at birth		
Large	11140	31.47
Average	13867	39.17
Small	10397	28.37
Age of child		
<1 year	3901	11.02
2-3 years	15762	44.52
>3 years	15741	44.46
Duration of breastfeeding		
Never breastfed	1745	4.93
< 12 months	14455	40.83
12+ months	19204	54.24
Total children ever born		
<5	20167	56.96
5+	15237	43.04
Partner’s education		
No education	20373	57.54
Primary+	15031	42.46
Maternal education		

No education	26323	74.35
Primary+	9081	25.65
Religion		
Orthodox	12375	34.95
Muslim	15819	44.68
Others	7210	20.36
Maternal age at childbirth		
<19	3520	9.94
19+	31884	90.06
Maternal Employment		
No	19355	54.67
Yes	16049	45.33
Survey period		
2000-2005	17,027	48.09
2011-2016	18377	51.91
Household level factors		
Asset-based wealth index		
Poorest	10,977	31.00
Poorer	7161	20.23
Middle	4833	13.65
Richer	5790	16.35
Richest	6643	18.76
Household size		
<6	15901	44.91
6+	19503	55.09
Sex of household head		
Female	5579	15.76
Male	29825	84.24
Source of drinking water		
Unimproved	22792	64.38
Improved	12612	35.62
Type of toilet facility		
Unimproved	30337	85.69
Improved	5067	24.31
Type of cooking fuel		
Solid fuel	34113	96.35
Clean fuel	1291	3.65
Community level drivers		
Regional category		
Established	19707	55.56
Emerging	12841	36.27
Urban	2856	8.07
Place of residence		
Rural	30201	85.30
Urban	5203	14.70
Total	35404	100.00

Source: Author's analysis using EDHS 2000-2016

8.4.2. Results of Bivariate Analysis

Table 8-2 shows the association between each explanatory variable and under-five mortality. Maternal education, religion, age at childbirth and employment status; partner's education, place of birth, total number of children ever born, duration of breastfeeding, child sex, age of child, and child size at birth were significantly (p<0.001) associated with under-five mortality at individual-level. From the household level variables, the household asset-based wealth index, household size, source of drinking water, type of sanitation facility, and type of cooking fuel were significantly (p<0.001) associated with under-five mortality. However, under-five mortality was not statistically (p<0.2) associated with sex of the household head. The two community-level factors (regional category and place of residence) has shown statistically significant associated (p<0.001) with under-five mortality (Table 8-2).

Table 8-2: Bivariate analysis of explanatory variables by under-five mortality, Ethiopia, 2005-2016

Explanatory Variables	**Under-five mortality (N=35,404)**				**Chi-square**
	Alive		Dead		
	N	%	N	%	
Individual level drivers					
Sex of child					34.18***
Male	15947	92.28	1335	7.72	
Female	16406	90.53	1716	9.47	
Place of delivery					59.80***
Home	27439	90.90	2746	9.10	
Health facility	4914	94.16	305	5.84	
Child size at birth					54.62***
Large	10017	89.92	1123	10.08	
Average	12835	92.56	1032	7.44	
Small	9501	91.38	896	8,62	
Age of child					45.75***
<1 year	3645	93.44	256	6.56	
2-3 years	14481	91.87	1281	8.13	
>3 years	14227	90.38	1514	9.62	
Duration of breastfeeding					6.30***
Never breast feed	689	39.48	1056	60.52	
< 12 months	13749	95.12	706	4.88	
12+ months	17915	93.29	1289	6.71	
Total children ever born					37.42***
<5	18589	92.18	1578	7.82	
5+	13764	90.33	1473	9.67	
Partner's education					69.98***
No education	18399	90.31	1974	9.69	
Primary+	13954	92.83	1077	7.17	
Maternal education					68.30***
No education	23864	90.66	2459	9.34	
Primary+	8489	93.48	592	6.52	
Religion					8.13**
Orthodox	11346	91.68	1029	8.32	
Muslim	14382	90.92	1437	9.08	
Others	6625	91.89	585	8.11	
Maternal age at child birth					59.29***
<19	3095	87.93	425	12.07	
19+	29258	91.76	2626	8.24	
Maternal Employment					7.92***

No	17761	91.76	1594	8.24	
Yes	14592	90.92	1457	9.08	
Survey period					164.79***
2000-2005	15221	89.39	1806	10.61	
2011-2016	17132	93.23	1245	6.77	
Household level drivers					111.97***
Asset-based wealth index					
Poorest	10052	91.57	925	8.43	
Poorer	6382	89.12	779	10.88	
Middle	4447	92.01	486	7.99	
Richer	5232	90.36	558	9.64	
Richest	6240	93.93	403	6.07	
Household size					230.45***
<6	14132	88.87	1769	11.13	
6+	18221	93.43	1282	6.57	
Sex of household head					1.86
Male	27281	91.47	2544	8.53	
Female	5072	90.91	507	9.09	
Source of drinking water					40.47***
Unimproved	20667	90.68	2125	9.32	
Improved	11686	92.66	926	7.34	
Type of toilet facility					39.80***
Unimproved	27606	91.00	2731	9.00	
Improved	4747	93.68	320	6,32	
Type of cooking fuel					31.17***
Solid fuel	31118	91.22	2995	8.78	
Clean fuel	1235	95.66	56	4.34	
Community level drivers					
Regional Category					19.28***
Established	17968	91.18	1739	8.82	
Emerging	11712	91.21	1129	8.79	
Urban	2673	93.59	183	6.41	
Place of residence					54.00***
Rural	27461	90.93	2740	9.07	
Urban	4892	94.02	311	5.98	

**** p<.01, ** p<.05,*
Source: Authors analysis using EDHS 2000-2016

8.4.3. Results of Multilevel Analysis

Table 8-3 presents the results of multilevel logistic regression analysis for the determinants of under-five mortality. The null model was used to explore the appropriateness of multilevel modeling which showed statistical significance($p<0.001$). At the community level, under-five children residing in rural areas had significantly ($p<0.001$) higher likelihood of death as compared to those children living in urban areas in both Model I and II. In Model III, the community level variables were not significantly ($p<0.05$) associated with under-five mortality in multilevel logistic regression analysis.

At the household level, under-five children living in the larger households with at least six household members had a significantly (p<0.001) higher likelihood of mortality compared to those living with less than six members of the households. Children from households with improved source of drinking water had significantly lower (p<0.001) likelihood of death than those living in households with unimproved source of water (Models II and III). Nevertheless, sex of household head, household asset-based wealth index, type of sanitation facility and type of cooking fuel were not significantly (p<0.05) associated with under-five mortality in the final model (Model III) of multilevel logistic analysis (Table 8-3).

Among the individual level variables used in Model III, child sex, child size at birth, duration of breastfeeding, parental education, maternal education, maternal age at childbirth, and maternal employment status were found to be statistically significant factors to determine under-five mortality. Female under-five children had significantly (p<0.001) lower likelihood of death than male children. Children born with larger and average size at birth had a significantly (p<0.001) lower likelihood of mortality compared to those born with small size at birth as subjectively reported by mothers. Children born from mothers who had more than five children ever born had significantly (p<0.001) higher chance of death than those born from mothers who had less than five children ever born. Children born from mothers who had uneducated partners had significantly (p<0.001) higher chance of mortality than those born from mothers who had educated partner. Similarly, children born from uneducated, younger and unemployed mothers had significantly (p<0.001) higher likelihood of mortality than those born from educated, adult and employed mothers. Under-five mortality was significantly (p<0.001) higher in the period 2000-2005 compared to the 2011-2016. However, place of birth, child age in months, and maternal religion were not significantly ($p<0.05$) associated with under-five mortality in multilevel logistic analysis (Table 8-3).

Table 8-3 has shown that the inclusion of individual level (level 1) explanatory variables into the model increased the effects of community variation from 0.011 (null model) to 0.017 (Model III). This indicates a minimal variation of under-five mortality between regions and rural-urban settings. Similarly, the household variation also decreased from 0.271 (in Model 0) to 0.233 (Model III), which suggests a substantial variation between communities (regions and urban rural areas) and households in under-five mortality. Furthermore, the estimated community level MOR increased from 1.239 (Model 0) to 1.301(final model) while household level MOR decreased from 2.891 to 2.623. This suggests existence of variation between households in under-five mortality in the country. The values of AIC and BIC also decreased from 20580.7 and 20606.12 (Model 0) to 16522.83 and 16760.12 (in Model III), respectively. The lower values of AIC and BIC are evident for better model fit of the final model (Model III) compared to the rest of the models constructed. Furthermore, likelihood ratio test (LR test) showed statistically significant associations for the fitted multilevel models and indicated good selection of the models fitted for multilevel analysis.

Table 8-3: Results of multilevel analysis of under-five mortality (N=35,404) Ethiopia, EDHS 2000-2019

Explanatory variables	Model 0 Coef. [CI]	Model I Coef. [CI]	Model II Coef. [CI]	Model III Coef. [CI]
Community-level attributes				
Region: Established(ref)				
Emerging		.027[-.068, .122]	.032[-064, .127]	.036[-.084, .157)
Urban		-.159[-.359, .040]	-.041[-.246, .165]	-.012[-.251, .227]
Place of residence: Urban(ref)				
Rural		.457[.306, .609] ***	.295[.117, .472] ***	.132[-.078, .034]
Household-level attributes				
Household size: (+6) (ref)				
Less than 6			-.665[-.752, -.577] ***	-1.138[-1.261, -1.014] ***
Household head sex: (female) (ref)				
Male			-.034[-.152, .084]	-.010 [-.141, .121]
Wealth status: Poor (ref)				
Non-poor			-.061[-.158, .037]	-.079[-.189, -.032]
Source of drinking water: (unimproved)				
Improved			-.159[-.264, -.054] ***	-.170[-.287, -.053] ***
Type of toilet: unimproved(ref)				
Improved			-.162[-.318, -.006] **	-.142[-.317, .033]
Type of cooking fuel: Solid(ref)				
Cleaned fuel			-.418[-.754, -.083] **	-.322 [-.717, .072]
Individual-level attributes				
Sex of child: female(ref)				
Male				.197 [.104, .290] ***
Place of birth: Home (ref)				
Health facility				-.126[-.316,.064]
Child age in months: (0-11months)				
12-36 months				079[-.100, 2.57]
37-59 months				.109[-.083, .301]
Size at birth: Small (ref)				
Average				-.291[-.402, -.179] ***
Large				-.229[-.347, -.111] ***
Duration of breastfeeding: Never(ref)				
Less than 12 months				-4.118[-4.33, -3.91] ***
12 and above months				-3.74[-3.93, -3.55] ***
Total children ever born: (<5, ref)				
5+				.832[.706, .959] ***
Partner's education: Primary + (ref)				
No education				.164[.049,.278] ***
Maternal education: Primary + (ref)				
No education				.219[.081,.357] ***
Mother's religion (Orthodox)				
Muslim				.120[-009, .248] *
Others				.005[-.140, .149]
Maternal age at child birth: (<19, ref)				
>19				-.397[-.549, -.244] ***
Maternal employment: No (ref)				
Yes				.162[.062, .262] ***
Survey period: 2000-2011(ref)				
2016-2019				-.618[-.748, -488] ***
Constant	-2.89[-2.98, -2.79] ***	-3.28[-3.46,3.10] ***	-2.64[-2.87, -2.40] ***	.893[.511, 1.275] ***
Random effect				
Community level variance	.051 [.023,.108]	.054[.026, .111]	.048[.022,.106]	.077[.041, .145]
Household level variance	1.24 [1.03,1.50]	1.23 [1.012,1.49]	1.12[.914,1.372]	1.02[.783, 1.335]
ICC community	0.011	0.012	0.011	0.017
MOR community	1.239	1.248	1.232	1.302
ICC household	0.271	0.268	0.251	0.233
MOR household	2.891	2.877	2.744	2.623
AIC (smaller is better)	20580.7	20527.8	20284.27	16522.83
BIC (smaller is better)	20606.12	20578.65	20385.97	16760.12
LR test (Chi^2)	214.65***	58.90***	255.53***	3793.44***

**** p<.01, ** p<.05, * p<.1*

Source: Authors analysis using EDHS 2000-2016

8.4.4. Results of Multivariate Decomposition Analysis

Table 8-4 describes multivariable decomposition analysis of maternal education-based inequalities in under-five mortality between the years 2000 and 2016. The results of the decomposition analysis showed that 31% of observed maternal education-based inequalities in under-five mortality could be attributed to differences in explained characteristic effects, whereas 69% would be to due difference in unexplained component. Minimizing the gap in the number of children ever born, and partner's education status can significantly ($p<0.001$) attribute to reduce maternal education-based inequalities in under-five mortality by 61.09% and 24%, respectively. However, household size could significantly($p<0.001$) contribute to widen the gap in maternal education-based inequalities in under-five mortality by 46.93%.

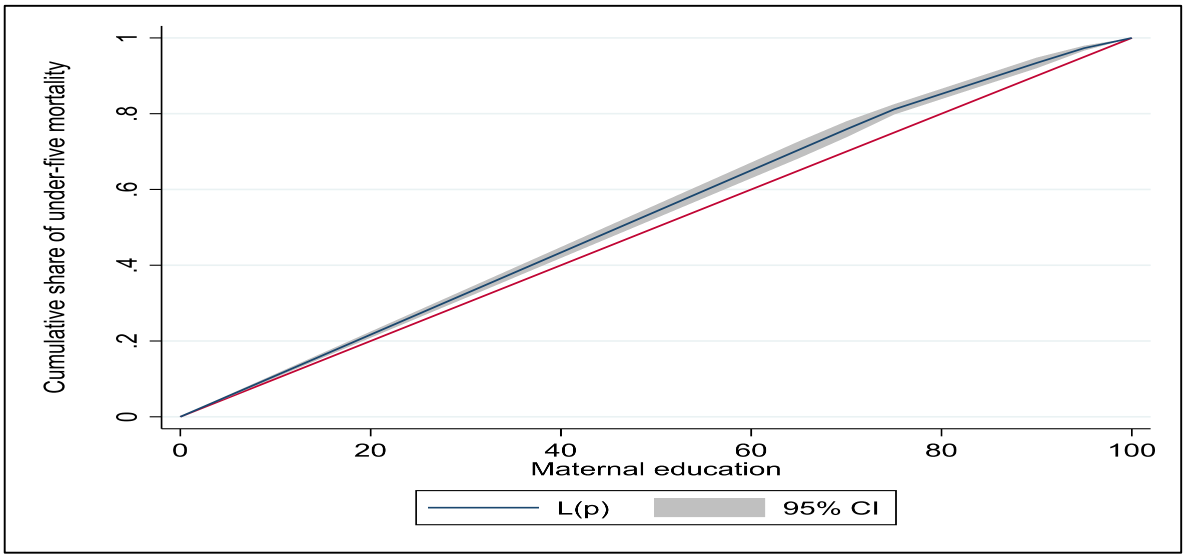
Table 8-4: Multivariable decomposition of maternal education in under-five mortality in Ethiopia, 2000-2016

Under-five mortality	Coef.	se	p-value	[95% CI]	Percent
Overall					
Explained gap (E)	0.009	0.002	0.000	[.005, .013]	31.00
Unexplained gap (C)	0.012	0.004	0.000	[.012, .027]	69/00
Due to Difference in Characteristics (E)					
Household size	-0.013	0.001	0.000	[-.015, -.012]	--46.93
Source of drinking water	0.002	0.001	0.053	[-.0001, .003]	5.65
Child sex	0.004	0.001	0.000	[.002, .006]	0.02
Child size at birth	-0.001	0.0003	0.029	[-.0011, -.0001]	-2.19
Duration of breastfeeding	-0.001	0.0001	0.000	[-.0007, -.0005]	-2.14
Total children ever born	0.017	0.001	0.000	[.015, .019]	61.09
Partner's education	0.001	0.002	0.000	[.003, .0105]	24.28
Maternal age at child birth	-0.002	0.0003	0.000	[-.003, -.00017]	-7.88
Maternal employment	-0.0003	0.0001	0.067	[-.001, .000017]	-0.89
Due to Difference in Coefficients (C)					
Household size	0.018	0.005	0.002	[.007, .030]	64.58
Source of drinking water	0.012	0.004	0.001	[.005, .019]	42.15
Child sex	-0.005	0.003	0.117	[-.012, .001]	-18.75
Child size at birth	-0.003	0.002	0.083	[-.007, .004]	-11.14
Duration of breastfeeding	-0.001	0.003	0.859	[-.007, .006]	-1.99
Total children ever born	-0.001	0.002	0.589	[-.005, .003]	-4.10
Partner's education	-0.0001	0.002	0.944	[-.003, .003]	-0.39
Maternal age at child birth	-0.001	0.001	0.662	[-.003, .002]	-2.04
Maternal employment	0.0002	0.003	0.948	[-.006, .007]	0.75
_cons	-0.0002	0.012	0.999	[-.023, .023]	-0.06

Source: Authors analysis using EDHS 2000-2016.

8.4.5. Inequalities in U5M Using Concentration Index

Figure 8-1 illustrates the concentration curve for under-five mortality by maternal education. The concentration curve was shown above the equality line indicating that under-five mortality was more concentrated among children born from mothers who had lower educational status in Ethiopia during the study period. Concentration index, the area between equality line and concentration curve, was -0.072 (p<0.001) which indicates the existence of inequalities in under-five mortality, and the inequality disfavored children born from uneducated mothers in the country.



Source: Authors analysis using EDHS 2000-2016

Figure 8-1: Concentration curve of Under-five mortality, Ethiopia, 2000-2016

8.4.6. Results of Trend Analysis

Table 8-5 shows results of the trend analysis of the maternal education-based inequalities in under-five mortality along with other factors. Maternal education, partner's education, household size and number of children ever born were used for trend analysis based on observed behavioral effect results in the multivariate decomposition analysis model above. The decomposition rate analysis result revealed that the overall absolute inequalities in under-five mortality was declined by 0.14

in the period of 2000-2005 and 0.32 during the period between 2000 and 2016 indicating about 56.25 percent of change. About 43.12% and 56.95% of the decline in under-five mortality can be attributed to narrowed gap due to maternal and parental education during the survey period, respectively. However, the household size seems a potential contributor for widening the gap in under-five mortality.

Table 8-5: Trends in under-five mortality inequality by maternal education in Ethiopia, 2000-2019.

Explanatory variables	Survey periods 2000-2005		2000-2011		2000-2016	
	D*	%	D	%	D	%
Maternal education	-0.04	29.84	-0.11	37.74	-0.14	43.12
Partner's education	-0.08	58.58	-0.16	52.99	-0.18	56.95
Household size	0.01	-7.17	0.008	-2.75	0.013	-3.93
Total children ever born	-0.03	18.75	-0.04	12.05	-0.01	3.86
Overall	-0.14	100	-0.30	100	-0.32	100

*Absolute difference in proportion of under-five mortality

Source: Authors construction using EDHS 2000-2019

8.5. Discussion

The present study primarily aimed to examine trends in maternal education-based inequalities in under-five mortality in Ethiopia using the four round nationally representative survey data collected between the years 2000 and 2016. We used multilevel, multivariate decomposition, concentration index and decomposition rate analyses. Our multilevel analysis result revealed that some household and individual level factors had statistically significant association with under-five mortality. This finding is consistent with studies conducted in Ethiopia (Wolde & Bacha, 2022; Yalew et al., 2022) and other developing countries (Bado & Susuman, 2016; Sastry, 2020).

At the household level, our finding revealed that under-five children who are living in the larger households (with 6+ members) faced higher likelihood of mortality compared to those children who are living in smaller (at most five members) households, which consistent with studies (Ahinkorah et al., 2020; Ekholuenetale, Wegbom, et al., 2020; Zewudie et al., 2020). Notably, the households with smaller members could be linked with good health practice and proper child health behavior as well as optimal feeding practices that could directly or indirectly contribute for better child survival compared to the larger households. In addition, children living in households using unsafe source of drinking water were found to have higher chance of mortality compared to those from households with improved source of water. Our finding is in line with previous studies conducted in Ethiopia (Hailu et al., 2021; Mebrahtom et al., 2022). One possible explanation could be the benefits associated with safe water as it is important to prevent water-borne diseases, including diarrheal, acute respiratory infections and neglected tropical diseases caused childhood mortality.

At the individual level, the present study finding showed that under-five male children were likely to have a higher likelihood of mortality than female children, which is similar to the previous study (Wolde & Bacha, 2022). This can be explained by sex differences in genetic and biological makeup (Pongou, 2013). The likelihood of death of under-five children differed by mothers perceived child size at birth. Our analysis indicated that the small sized children at birth had greater likelihood of mortality compared to those children perceived to have a large size at birth, which is consistent with another study finding (Ezeh et al., 2015).

In the present study, maternal education was found to have significant effect on under-five mortality. Under-five children born from uneducated mothers were found to have a greater likelihood of mortality than those born from educated mothers, which is supported by the previous studies conducted in Ethiopia (Kiross et al., 2019; Tibebu et al., 2022; Wolde & Bacha, 2022). The recent evidence indicates that mothers' education could help reduce under-five mortality by adopting greater access to child healthcare, including use of child vaccination, and safe water

(Moradhvaj & Samir, 2023). Our multivariate decomposition analysis finding also revealed that about one-third (31%) of the maternal education-based inequalities in under-five mortality could be explained by observed characteristic effects. The present study also found that household size could have an impact to widen maternal education-based inequalities in under-five mortality by 46.93%. Moreover, the concentration index analysis finding showed that under-five mortality was more concentrated, and disfavored children born from uneducated mothers (with concentration index = -0.072) during the study period. Furthermore, the decomposition rate analysis result revealed that the overall absolute inequalities in under-five mortality was declined by 0.14 in the period of 2000-2005 and 0.32 during the period between 2000 and 2016 indicating about 56.25 percent of change. This study found that about 43.12% of the decline in under-five mortality would be attributed to narrowed gap in maternal education during the survey period in the country.

Finally, it is important to mention the strength and limitation of the present study. The strength of the study was the use of four rounds of nationally representative cross-sectional surveys data which enables in the generalization of the study findings to a larger population in Ethiopia. The findings help policy makers and regional administrators in their planning, monitoring and evaluation of progresses in U5M. In addition, application of multilevel, decomposition and concentration index analysis could be a strength of the study as it helps to fill gaps in the existing literature. However, the study is not immune from limitations. The study was limited merely to the variables listed in the methodology part, and there might be some important variables not included in the analysis. Moreover, as the data were collected based on cross-sectional design, drawing cause-effect relationship among the explanatory and outcome variable was not possible. Furthermore, given most mothers had little or no education, some of the variables used in the analysis (such as child size at birth) might be influenced by possible recall bias and perception of the respondents.

8.6. Conclusion

Maternal education was found to have substantial impact on inequalities in under-five mortality in Ethiopia. About one-third (31%) of the maternal education-based inequalities in under-five mortality could be explained by observed characteristic effects. In addition, the narrowed gap in maternal education had contributed for about 43% of decline in under-five mortality in the past 16 years in the country. Therefore, it is instrumental to focus on maternal education to reduce the existing inequalities in under-five mortality. Furthermore, revising the existing population and health policies further to link the child survival issues with education sector is also crucial to achieve sustainable development goal targets related to under-five mortality.

CHAPTER NINE

Population Level Impacts of Risk Factors of Childhood Anemia, Undernutrition, and Under-five Mortality in Ethiopia

(Manuscript submitted for publication @ BMC Pediatrics; and authors are Negussie Shiferaw and Nigatu Regassa)

9.1. Background

Childhood anemia, undernutrition, and under-five mortality remain prime public health concerns in developing countries (Khulu et al., 2022; Tessema et al., 2023). According to the World Health Organization (WHO), childhood anemia refers to a blood hemoglobin concentration less than 11 g/dl (WHO, 2001); undernutrition denotes an insufficient intake of nutritious food, which results in stunting, wasting, and underweight (WHO, 2006); and under-five mortality is defined as the death of a child before the age of five (WHO, 2000).

Despite the progress and achievements made in the past two decades, a large number of children are suffering from childhood anemia, undernutrition, and under-five mortality worldwide. Globally, an estimated 148.1 million under-five children were affected by stunting in 2022 alone. Of these, 43% of stunted children lived in Africa (WHO/UNICEF/WB, 2023). In addition, about 269 million under-five children were anemic in 2019, and more than 60% of anemic children also resided in Africa (Stevens et al., 2022b). In addition, about 5.0 million children died before reaching their fifth birthday at the global level in 2021 (WHO, 2023b). Worryingly, children born in sub-Saharan Africa are subject to the highest under-five mortality rate of 74 deaths per 1000 live births, which is 15 times higher than the risk for children in Europe and Northern America and 19 times higher than children born in the region of Australia and New Zealand in 2021 (WHO/UNICEF/WB, 2023). Currently, Global child health task force is urging 54 African countries, including Ethiopia, to accelerate efforts to achieve the Sustainable Development Goal

(SDG) 2030 targets of under-five mortality of 25 deaths or fewer per 1000 live children (Child Health Task Force, 2023).

In Ethiopia, more than half (57%) of children aged 6-59 months were estimated to be anemic in 2016 (Central Statistical Agency (CSA) [Ethiopia] & ICF., 2016). The country had about 37% of under-five children suffering from stunting and under-five mortality rate of 59 deaths per 1000 live births in 2019 (EPHI & ICF, 2021). Based on the reported burden of global under-five mortality, the country ranked third in Africa and tenth in the world (Dheresa et al., 2022). In addition, Ethiopia ranked 144 out of 166 countries with a 54.5 score of sustainable development index based on the 2023 Sustainable Development Goal monitoring report (Sachs, et al., 2023). Understanding the key factors and their contribution on childhood morbidity (undernutrition and anemia) and mortality (under-five mortality) will be helpful to accelerate the reduction in childhood anemia, undernutrition and under-five mortality, and further to achieve SDG targets related to child morbidity and mortality.

Previous studies (Debela et al., 2023; Gesese & Khot, 2023; Negussie & Nigatu, 2023a; Sahiledengle et al., 2022; Shaka et al., 2020; Workie et al., 2020; Zewudie et al., 2020) pointed out geographic location, place of residence, household asset-based wealth index, household size, maternal education, maternal age at birth, maternal employment status, and child size at birth as the key factors significantly associated with childhood undernutrition in Ethiopia. Some other studies (Anteneh & Geertruyden, 2021; Heinrichs et al., 2021; Jember et al., 2021; Negussie & Nigatu, 2023b) documented that childhood anemia is significantly associated with the geographic location, place of residence, household asset-based wealth index, the household size, maternal education, maternal anemia and employment status, place of birth, age of child in months, and child size at birth as reported subjectively by mothers. Other studies (Argawu & Mekebo, 2022; Ayele et al., 2022; Tessema et al., 2022; Yemane, 2022) also identified the household size, source of drinking water, parental and maternal education, maternal age at birth and employment status, child's size at birth, and duration of breastfeeding as the key associated factors with under-five mortality.

Studies on the major determinants of child survival are ample, but the extent to which these factors contribute to the overall burden of child survival (childhood anemia, undernutrition, and under-five mortality) in Ethiopia is scarce. Therefore, this study poses the question "*How much is the proportional reduction in childhood undernutrition, anemia, and under-five mortality by removing the key risk factors?*" The finding of the study will help identify attributable risk factors of childhood undernutrition, anemia, and under-five mortality, and will be used as input for development partners, and policymakers to design and implement risk-specific and targeted interventions in the country.

9.2. Data source and methods

9.2.1. The Study Context

Ethiopia has federal system with twelve regional states, including three recently appeared regions from the previous Southern Nations, Nationalities and Peoples Region (SNNPR), and two chartered city administrations. According to the 2022 United Nations Development Program (UNDP) estimate, the country's population was about 123 million with 2.6% annual growth rate, and this makes the country the second most populous country in Africa (UNDP, 2022).

Ethiopia is prone to natural and manmade shocks and stresses that affect households, community and environmental system resilience (USAID & Mercy Corps, 2019). The periodic occurrence of communicable and non-communicable disease outbreaks pose a challenge to the health system in the country (MOH, 2021). The government of Ethiopia has shown commitment to global agendas, including Sustainable Development Goals and Seqota Declarations to achieve child survival targets and ending childhood undernutrition by 2030 (MOH, 2021). To accelerate reduction in childhood undernutrition, the country has developed and endorsed food and nutrition policy and strategies, including Food and Nutrition Policy (FDRE, 2018) and the National Nutrition Program (NNP) I (FDRE, 2008), NNP II (FDRE, 2016) and National Strategy for Newborn and Child survival (FMOH-FDRE, 2016). However, the country is still experiencing a range of challenges related to child survival contributing to the existing childhood anemia, undernutrition and under-five mortality (Central Statistical Agency (CSA) [Ethiopia] & ICF., 2016).

9.2.2. Data Source

The study used nationally representative data from the three rounds of Ethiopian Demographic and Health Survey (EDHS) data collected from year 2005 to 2016. The datasets were downloaded from DHS website (http://dhsprogram.com) based on secured online permission. The study used children's files that contain information about socioeconomic and demographic characteristics for under-five children, their parents and households. The pooled three rounds of EDHS data comprised of 29,831 under-five children used for the analysis.

9.2.3. Study Variables

Outcome variables: Childhood undernutrition, childhood anemia and under-five mortality were the three outcome variables of the study. Childhood anemia was categorized into dummy variable where a child is considered to be anemic and assigned value of 1 if the child had severe, moderate or mild anemia level, and 0 if the child is not anemic. Childhood undernutrition status was categorized as undernourished and coded as 1 if the child had any form of anthropometric failure, and as nourished with assigned value of 0 if the child had no anthropometric failure. Under-five mortality was coded as 1 if the child died between 0 and 59 months and 0 if the child was alive at least until the age of 59 months (Croft et al., 2018).

Exposure variables: Framing and selection of the exposure variables was done based on the well-known child survival conceptual framework developed by Mosley and Chen(1984), and review of the related literatures (Anteneh & Geertruyden, 2021; Argawu & Mekebo, 2022; Ayele et al., 2022; Negussie & Nigatu, 2023b, 2023a). All exposure variables were coded dichotomously for analysis purpose (Rückinger et al., 2009). In this study, the old eleven administrative regions of Ethiopia were regrouped into two regional categories as follows: emerging regions (Afar, Somali, Benishangul-Gumuz, and Gambella), and established regions (Amhara, Oromia, Harari, Southern Nations Nationalities, and People's Region (SNNPR) and Tigray, including Addis Ababa and Dire Dawa City Administrations) for analysis purpose. The five quintiles of the household asset-based wealth index were regrouped into two as poor (poorest/poorer) and non-poor (medium, richer and richest). The parental education (maternal/paternal) status was recategorized as (no formal education vs primary+). In addition to these exposure variables, place of residence (rural vs urban), household size (<5 vs 5+), household head (male vs female), source of drinking water (improved vs unimproved), type of toilet facility (improved vs unimproved), type of cooking fuel (cleaned vs solid), maternal age at child birth (<18 vs 18+), maternal employment status (employed vs unemployed), maternal anemia status (anemic vs non-anemic), total children ever born (<4 vs 4+), antenatal visit (<4 vs 4+), place of birth (home vs health facility), child sex (female vs male), duration of breastfeeding (<6 months vs 6+ months), and child size at birth (small vs average and above) were used as control variables for the present study.

9.2.4. Statistical Analysis

We used STATA 17 for data management and analysis. Children with missing and unknown responses for source of drinking water, type of sanitation facility, type of cooking fuel, place of delivery, duration of breastfeeding, anthropometric measures (height/length/weight), and size at birth (which accounts for less than 3% of the sample) were excluded from statistical analysis. Descriptive analysis was used to describe the background characteristics of the study participants, data were weighted for descriptive analysis using DHS recommendation. Multicollinearity effect of the predictor variables was tested using Variance Inflation Factor(VIF) with cutoff value of 2.5 (Johnston et al., 2018), the value of VIF for each variable was less than 2.5 with mean VIF value of 1.33, 134 and 1.34 for childhood anemia, undernutrition and under-five mortality, respectively, indicating the absence of multicollinearity effect among predictor variables.

Bivariate logistic regression was employed to select the exposure variables with p-value < 0.2. Multiple logistic regression analyses were conducted to explore the association between selected predictor variables and the three outcome variables, and Hosmer-Lemeshow test was used to test the goodness of fit for our models (Hosmer et al., 1997). A p-value <0.05 was used as a measure of statistical significance in our models. Population Attributable Fractions (PAFs) were used to estimate the impact of associated risk factors with childhood anemia, undernutrition and under-five mortality at the population level using STATA user command “punaf” (Newson, 2013) after running logistic regression models. “punaf” essentially implements the method for estimating PAFs for cross-sectional studies recommended by Greenland and Drescher (Greenland & Drescher, 1993), and could be used for large scale surveys with multiple risk factors as suggested by Ruckinger et al. (2009). Accordingly, we employed the procedural steps suggested by Ruckinger and his colleagues (Rückinger et al., 2009) as follows:

1. Coded the risk factor as a binary variable. We assumed that all individuals were not exposed to the risk factor, regardless of their actual status.
2. Used the following formula to estimate the predicted probabilities for each-individual using the modified dataset:

$$pp_i = \frac{1}{1+exp\,(-(\alpha+\beta'\,x_i)}$$

   where α is the intercept, β is the vector of coefficients for the explanatory, and xi is the vector of observations for the explanatory, with the risk factor set to zero for all individuals.
3. Summed up all the predicted probabilities to get the adjusted number of cases of child survival that would occur if the risk factor was absent in the population.
4. Finally "punaf" Stata user command has been used to enable normalization and variance-stabilizing transformation with the following formula(Newson, 2013):

$$\log(PUF) = \log(1 - PAF)$$

   where PUF stands for Population Unattributable Fraction, and PAF refers to Population Attributable fraction.

9.3. Results

9.3.1. Results of Descriptive Analysis

Table 9-1 describes the characteristics of the 29,831 under-five children. Close to 62% and 84% of children were living in established regions and rural areas, respectively. Nearly 50% of children were living within the poor households and more than 73% of children were living with five and above family members. More than 86% and 96% of children were belonging to households who use unimproved toilet and solid fuel. About 54% and 71% of children's fathers and mothers had no formal education, respectively. Close to 71% of children were born to mothers who had more than three ever born children. About 62% of children belonged to unemployed mothers. About 51% and 82% of children were females and delivered at home, respectively. Nearly 29% and 48% of children had small size at birth and breastfed for less than six months, respectively.

Table 9-1: Background characteristics of study participants, N=29,831

Background Characteristics	**N**	**%**
Administrative regions		
Emerging	11,403	38.23
Established	18,428	61.77
Place of residence		
Rural	25,050	83.97
Urban	4,781	16.03
Household asset-based status		
Poor	14,710	49.31
Non-Poor	15.121	50.69
Household size		
< 5	7,919	26.55
5+	21,912	73.45
Household head		
Female	4,893	16.40
Male	24,938	83.60
Source of drinking water		
Improved	11,737	39.34
Unimproved	18,094	60.66
Type of toilet facility		
Improved	4,211	14.12
Unimproved	25,620	85.88
Type of cooking fuel		
Cleaned	1,179	3.95
Solid	28,652	96.05
Paternal Education		
No formal education	16,055	53.82
Primary and above	13,776	46.18
Maternal education		
No formal education	21,114	70.78
Primary and above	8,717	29.22
Maternal age at child birth		
< 18 years	1,828	6.13
18 years and above	28.003	93.87
Maternal anemia status		
Anemic	7,284	30.49
Non-anemic	16,608	69.51
Total children ever born		
< 3	8,701	29.17
3+	21,130	70.83
Maternal employment		
Unemployed	18,421	61.75
Employed	11,410	38.25
Child sex		
Female	15,294	51.27
Male	14,537	48.73
Place of birth		
Home	24,457	81.99
Health facility	5,374	18.01
Child size at birth		
Small	8,579	28.76
Average and above	21,252	71.24
Duration of breastfeeding		
< 6 months	14,312	47.98
6 months and above	15,519	52.02
Total	**29,831**	**100**

9.3.2. Results of Bivariate Logistic Analysis

Table 9-2 summarizes the bivariate logistic regression of 18 predictors selected for the present study. The variables were selected based on review of literature. Maternal age at child birth and child sex were not associated with childhood anemia while region and sex of household head were not associated with childhood undernutrition at p-value <0.2. In addition, sex of household head and maternal employment status were not associated with under-five mortality at p-value <0.2. Since these variables had p-value>0.2, they were not selected for multivariable logistic regression.

Table 9-2: Bivariate logistic regression of predictors by childhood anemia, undernutrition and mortality in Ethiopia

	Anemia (N=19,731)			Undernutrition (N=20,777)			Under-five mortality (N=29,831)		
Predictors	Odds ratio	95%Cl	p-value	Odds ratio	95%Cl	p-value	Odds ratio	95%Cl	p-value
Regions									
Emerging	1.8211	1.72-1.93	0.000	1.023	0.97-1.08	0.412	1.118	1.03-1.22	0.011
Established(ref)									
Place of residence									
Rural	1.358	1.56-1,47	0.000	2.336	2.17-2.52	0.000	1.582	1.39-1.81	0.000
Urban (ref)									
Household status									
Poor	1.616	1.52-1.71	0.000	1.676	1.59-1.77	0.000	1.193	1.09-1.30	0.000
Non-Poor(ref)									
Household size									
< 5(ref)									
5+	1.104	1.03-1.18	0.003	1.176	1.11-1.25	0.000	0.519	0.47-0.57	0.000
Household head									
Female	1.121	1.04-1.21	0.002	0.97	0.91-1.04	0.386	0.978	0.87-1.09	0.692
Male(ref)									
Drinking water									
Unimproved	1.184	1.12-1.26	0.000	1.356	1.28-1.43	0.000	1.194	1.09-1.31	0.000
Improved(ref)									
Type of toilet facility									
Unimproved	1.198	1.10-1.30	0.000	2.168	2.01-2.34	0.000	1.672	1.45-1.93	0.000
Improved(ref)									
Type of cooking fuel									
Cleaned (ref)									
Solid	1.577	1.34-1.85	0.000	3.979	3.36-4.72	0.000	2.312	1.70-3.14	0.000
Paternal Education									
No formal education	1.314	1.24-1.39	0.000	1.633	1.55-1.72	0.000	1.344	1.23-1.48	0.000
Primary+(ref)									
Maternal education									
No formal education	1.297	1.22-1.38	0.000	1.777	1.67-1.88	0.000	1.391	1.26-1.54	0.000
Primary+(ref)									
Maternal age at birth									
< 18 years	0.975	0.86-1.10	0.678	1.251	1.11-1.40	0.000	1.686	1.46-1.95	0.000
18+ years (ref)									
Maternal anemia									
Anemic	1.978	1.85-2.11	0.000	1.092	1.03-1.16	0.003	1.254	1.13-1.39	0.000
Non-anemic(ref)									
Children ever born									
< 3(ref)									

3+	1.125	1.06-198	0.000	1.354	1.27-1.43	0.000	1.348	1.22-1.49	0.000
Maternal employment									
Unemployed	1.606	1.52-1.70	0.000	0.949	0.89-1.00	0.057	0.982	0.90-1.07	0.685
Employed(ref)									
Child sex									
Female	1.034	0.97-1.09	0.247	1.144	1.09-1.21	0.000	1.288	1.18-1.40	0.000
Male(ref)									
Place of birth									
Home	1.103	1.03-1.19	0.008	2.206	2.06-2.36	0.000	1.566	1.38-1.78	0.000
Health facility(ref)									
Child size at birth									
Small	1.240	1.16-1.32	0.000	1.541	1.45-1.63	0.000	0,989	0.89-1.09	0.821
Average & above(ref)									
Breastfeeding duration									
< 6 months	1.692	1.59-1.79	0.000	1.696	1.60-1.80	0.000	0,848	0.78-0.93	0.000
6+ months(ref)									

9.3.3. Results of Multivariate Logistic Regression Analyses

Table 9-3 depicts the multivariable logistic regression analyses results for childhood anemia, undernutrition and under-five mortality. Administrative region, place of residence, household size, maternal anemia and employment status, place of birth, child size at birth as reported by mothers, and duration of breastfeeding had statistically significant association with childhood anemia at p-value <0.05. It is apparent that children living in emerging regions were 1.571 times more likely to be anemic compared to those living in established regions (OR=1.571, P<0.001). Children from the poor households were 1.4 times higher odds of being anemic than those living in non-poor households (OR=1.391, P<001). Children born from anemic and unemployed mothers were 1.81 and 1.42 times more likely to be anemic compared to those born from non-anemic (OR=1.808, P<0.001) and employed mothers (OR=1.417, P<0.001), respectively.

Table 9-3 also shows that place of residence, household size, type of toilet facility and cooking fuel, paternal and maternal education, maternal age at child and employment status, number of children ever born, child sex, place of birth, child size at birth and breastfeeding duration were significantly associated with childhood undernutrition at p<0.05. Children living in rural areas, poor households, and unimproved toilet user households were at least 1.2 times more likely to be undernourished than those from urban settings (OR=1.276, p<001), non-poor households (OR=1.213, p<001), and households using improved toilet facility, respectively. Likewise, children living in solid fuel user households had 1.7 times higher odds of being undernourished than those who are living in clean fuel user households (OR=1.696, p<001).

Children from unimproved toilet facility user households were 1.3 times higher odds of dying compared to those from improved toilet facility user households (OR=1.318, p<0.001). Children born from younger mothers (<18 years old) were 1.7 times more likely to die compared to those born from 18 and above years old mothers (OR= 1.690, p<0.001). Children born from mothers with three and above children ever born were 3.036 times higher odds of dying compared to those who were born from mothers with smaller number of children ever born (OR=3.036, p<0.001) (Table 9-3).

Table 9-3: Multiple logistic regression of predictors by childhood anemia, undernutrition and mortality, Ethiopia

	Anemia (N=19,731)			Undernutrition (N=20,777)			Under-five mortality (N=29,831)		
Predictors	Odds ratio	95%Cl	p-value	Odds ratio	95%Cl	p-value	Odds ratio	95%Cl	p-value
Regions									
Emerging	1.571	1.47-1.68	0.000				1.059	0.95-1,18	0.298
Established(ref)									
Place of residence									
Rural	1.146	1.02-1.29	0.022	1.276	1.15-1.42	0.000	1.148	0.93-1.41	0.192
Urban(ref)									
Household status									
Poor	1.391	1.30-1.49	0.000	1.213	1.14-1.29	0.000	0.968	0.86-1.09	0.591
Non-poor(ref)									
Household size									
< 5 (ref)									
5+	1.102	1.01-1.21	0.039	0.974	0.89-1.06	0.539	0.278	0.24-0.32	0.102
Household head									
Female	1.044	0.96-1.14	0.318						
Male (ref)									
Source of drinking water									
Unimproved	0.972	0.91-1.14	0.437	0.927	0.86-0.99	0.024	1.032	0.92-1.16	0.607
Improved(ref)									
Type of toilet facility									
Unimproved	0.968	0.87-1.07	0.540	1.291	1.17-1.43	0.000	1.318	1.08-1.60	0.006
Improved(ref)									
Type of cooking fuel									
Cleaned (ref)									
Solid	1.045	0.86-1.27	0.653	1.696	1.38-2.08	0.000	1.290	0.83-2.00	0.256

Paternal Education									
No formal education	1.069	0.99-1.15	0.056	1.199	1.12-1.28	0.000	1.116	0.99-1.25	0.061
Primary and above(ref)									
Maternal education									
No formal education	1.033	0.95-1.12	0.413	1.214	1.13-1.31	0.000	1.043	0.91-1.19	0.538
Primary+(ref)									
Maternal age at birth									
< 18 years				1.332	1.16-1.53	0.000	1.690	1.38-2.07	0.000
18+ years (ref)									
Maternal anemia									
Anemic	1.808	1.68-1.93	0.000	0.983	0.92-1.05	0.603	1.130	1.01-1.26	0.030
Non-anemic(ref)									
Children ever born									
< 3(ref)									
3+	1.054	0.96-1.15	0.264	1.092	1.00-1.19	0.048	3.036	2.54-3.62	0.000
Maternal employment									
Unemployed	1.417	1.33-1.51	0.000	0.871	0.82-0.92	0.000			
Employed(ref)									
Child sex									
Female				1.185	1.12-1.26	0.000	1.278	1.15-1.42	0.201
Male(ref)									
Place of birth									
Home	0.838	0.76-0.92	0.000	1.384	1.26-1.51	0.000	1.147	0.97-1.36	0.118
Health facility(ref)									
Child size at birth									
Small	1.146	1.07-1.23	0.000	1.486	1.39-1.58	0.000			
Average and above(ref)									
Breastfeeding duration									
< 6 months	1.888	1.77-2.01	0.000	0.791	0.75-0.84	0.000	0.717	0.64-0.79	0.000
6 months and above(ref)									
Constant	0.392	0.33-0.47	0.000	0.210	0.17-0.25	0.000	0.036	0.02-0.46	0.000
Hosmer-Lemeshow test	chi2 = 0.64		p=0.887	chi2 =4.09		p=0.252	chi2 =6.16		p=0.104

9.3.4. Results of Population Attributable Fraction Analysis

Table 9-4 shows the population estimates of attributable fraction of selected risk factors at the population level for childhood anemia, undernutrition and under-five mortality. Breast feeding duration was the most important risk factor associated with childhood anemia with relatively largest proportion (11.2%) of impact. Similarly, 8.6% of anemic children could have been prevented in the absence of unemployed mothers. Administrative regional category, place of residence, household asset-based wealth status, household size, maternal anemia and child size at birth were also significant risk factors with a total of 32.1% of combined impact at population level. The combined population level impact of all eight significant risk factors of childhood anemia yields 51.9%.

Place of residence, type of toilet facility, type of cooking fuel, and home delivery were key risk factors associated with childhood undernutrition whose combined impact at population level is about 55%. The combined population level impact of all eleven selected significant risk factors of childhood undernutrition amounts 73.9%. In addition, type of toilet facility, maternal age at child birth and number of children ever born to mother and breastfed duration were significant risk factors of under-five mortality with 72% of combined impact at population level (Table 9-4).

Table 9-4: Population attributable fractions for risk factors of childhood anemia, undernutrition and mortality, Ethiopia

	Anemia (N=19731)		Undernutrition(N=20,777)		Under-five mortality (N=29,831)	
Risk factors	OR [95%, CI]	PAF (%)	OR [95%, CI]	PAF (%)	OR [95%, CI]	PAF (%)
Emerging regions	1.58[1.47,1.68]	7.1%	-	-	-	-
Rural residence	1.14[1.03,1.27]	4.7%	1.26[1.13,1.40]	9.4%	-	-
Poor households	1.40[1.31,1.50]	7.2%	1.21[1.14,1,29]	4.8%	-	-
Household size (5+)	1.14[1.06,1.23]	4.3%	-	-	-	-
Unimproved toilet facility	-	-	1.32[1,19,1,44]	11.2%	1.47[1.22,1.77]	27.4%
Solid fuel use for cooking	-	-	1.62[1,34,1.97]	22.2%	-	-
Parental education (no education)	-	-	1.19[1.12,1,27]	4.5%	-	-
Maternal education (no education)	-	-	1.21[1,12,1.30]	6.5%	-	
Mothers age at birth (<18yrs)	-	-	1.33[1.16,1.51]	0.7%	1.72[1.41,2.11]	3.3%
Anemic mothers	1.82[1.69,1.95]	7.2%	-	-	1.16[1.04,1.29]	4.4%
Number of children ever born (3+)	-	-	1.07[0.99,1.15]	2.4%	3.19[2.68,3.79]	51.3%
Maternal employment(unemployed)	1.42[1.33,1.52]	8.6%	-	-	-	-
Home delivery	-	-	1.36[1.24,1.48]	12.2%	-	-
Child size at birth (small)	1.15[1.08,1,23]	1.6%	1.48[1.39,1.57]	5.3%	-	-
Breastfeeding for < 6 months	1.88[1.77,2.01]	11.2%	0.79[0.75,0.84]	-5.3%	0.71[0.64,0.79]	-13.9%
Total for all significant variables		**51.9%**		**73.9%**		**72.5%**

9.4. Discussion

To the best of our knowledge, this study was the first to examine the population level impacts of key risk factors of childhood undernutrition, anemia, and under-five mortality in Ethiopia. Our multivariate regression analysis evinced that administrative region (emerging regions), place of residence (rural areas), household asset-based wealth status (poor status), maternal anemic status (anemic mothers), mothers who had large total number of children ever born (3+), and duration of breastfeeding (lower than six months) found to be the key risk factors for childhood anemia. Likewise, the multivariable logistic regression analysis also witnessed that place of residence (rural areas), household asset-based wealth status (poor status), type of toilet facility (unimproved toilet), type of cooking fuel (solid fuel), paternal and maternal education status (no formal education), place of delivery (home delivery) and child size at birth (small size) were the key risk factors significantly associated with childhood undernutrition. Moreover, our analysis revealed that children living in households using unimproved toilet facilities, children born from younger mothers (<18 years old) and mothers with at least three children ever born had higher likelihood of dying before reaching age five compared to those living in improved toilet facility user households, born from 18 and above years old mothers and mothers with a total of less than three children ever born, respectively. This indicates that type of toilet facility (unimproved), maternal age at child birth (<18 years) and total number of children ever born are modifiable risk factors associated with under-five mortality in the present study.

Furthermore, PAFs analyses of risk factors of childhood anemia confirmed that 38.5% of occurrence of childhood anemia was attributed to five selected risk factors, including having large household size (5+), being poor household, being born from anemic and unemployment mothers, and being breastfed for less than six months. This indicates that controlling these five modifiable risk factors could possibly prevent about 39% of the reported burden of childhood anemia at the population level. The PAFs analysis also revealed that about 45.6% of occurrence of childhood undernutrition was attributed to unimproved toilet facility, solid cooking fuel, and home delivery in the population. This means that nearly half (46%) of the reported childhood undernutrition could potentially be reduced by removing these three modifiable risk factors in the target population. This shows that using improved sanitation facility, clean cooking fuel and health facility contribute to prevent about 46% of childhood undernutrition at population level. Likewise, about half (51.3%) the reported under-five mortality could potentially be averted by controlling the number of children ever born to mothers at population level. As a combined impact, 72% of the reported under-five mortality could possibly be averted by controlling type toilet facility, maternal age at child birth and number of children ever born to mother and breastfeeding duration at population level. It is important to note that we did not conduct comparison of our PAFs findings with other previous studies due to varying prevalence of risk factors (Rückinger et al., 2009).

Strengths and limitations

The present study has examined the proportion of reduction on childhood anemia, undernutrition and under-five mortality by removing modifiable risk factors at population level in Ethiopia. The findings will undeniably contribute to the existing literature gap and could be used as evidence for child survival program implementers and interventions, policy makers and future researches as far as we used nationally representative surveys. However, this study is not free from limitations. Firstly, as we used cross-sectional data collected at a time specific point in time, it is difficult to draw causal relationship between the predictors and outcome variables. Secondly, some of the risk factors which were not included (especially macro level factors) in the multivariable regression models might have affected the estimated level of PAFs.

9.5. Conclusion

This study focused on key modifiable risk factors associated with childhood anemia, undernutrition and under-five mortality in Ethiopia. The estimated attributable burdens of these modifiable risk factors were found to be substantial at population level. Therefore, the present study suggests that substantial reduction in the prevalence of childhood anemia, undernutrition and under-five mortality in the country is attainable if policies and child survival focused program interventions target low socioeconomic mothers and households and those who have low awareness on child health care, including breast feeding practice and use of safe sanitation facilities.

CHAPTER TEN

Spatial Variability of Child Survival in Ethiopia: Evidence from Nationally Representative Surveys

(Manuscript submitted for publication@ *Journal of Health, Population and Nutrition; and authors are Negussie Shiferaw and Nigatu Regassa*)

10.1. Background

Child survival is a critical marker of a thriving society and is recognized by the international community in the Sustainable Development Goal (SDG 3), which calls for all countries to reach an under-five mortality rate of 25 or fewer deaths per 1,000 live children by 2030 (United Nations, 2016). Although the global under-five mortality rate (U5MR) declined from 76 (in 2000) to 38 (in 2021) deaths per 1,000 live children, the U5MR was the highest (74 deaths per 1,000 live children) in Sub-Saharan Africa in 2021 (UN IGME, 2022). This indicates that the distribution of U5MR is uneven globally and the burden is higher in Sub-Saharan African (SSA) countries, including Ethiopia (Sato et al., 2023).

In addition to under-five mortality, the existing burden of childhood undernutrition continues jeopardizing under-five children's ability to survive and thrive in developing regions (WHO/UNICEF/WB, 2023). Yet, the Africa region had the highest burden followed by the South-East Asia region, where 56.2 and 49.8 million under-five children were affected by stunting in 2022, respectively (WHO, 2023c). Childhood anemia, is a strong indicator of overall child health, and affected 40% of all children aged 6-59 months globally in 2019, where Africa and South-east Asia are still the regions mostly affected (WHO, 2023a).

In Ethiopia, the prevalence of under-five mortality remains unacceptably high and unevenly distributed in the country (Liyew et al., 2021; Sato et al., 2023). For example, under-five mortality rate varied from 125 per 1000 live children residing in the Afar region to 39 per 1000 children in Addis Ababa City Administration in 2016 (Central Statistical Agency (CSA) [Ethiopia] & ICF., 2016). Besides, substantial regional variations were observed in the prevalence of childhood undernutrition, where underweight was highest (36%) in the Afar region, whereas stunting (47%) and wasting (23%) were highest in the Amhara and Somali regions of the country, respectively (Central Statistical Agency (CSA) [Ethiopia] & ICF., 2016). Furthermore, the prevalence of childhood anemia was highest in Somali region (83%), and lowest (42%) in the Amhara region (Central Statistical Agency (CSA) [Ethiopia] & ICF., 2016).

In this paper, child survival refers to childhood undernutrition, anemia, and under-five mortality. It is evident that these indicators are intertwined with the geographic location of the country (Liyew et al., 2021). Research is demanded to explore spatial patterns of child survival indicators, identify priority areas, and inform evidence-based policies and/or interventions in the country.

Although previous studies (Alemu et al., 2016; Endris et al., 2021; Fenta et al., 2021b; Jember et al., 2021; Liyew et al., 2021; Tessema et al., 2022) have conducted spatial analysis on child survival indicators in Ethiopia, these studies merely focused on a single indicator of child survival. To the best of our knowledge, there were no studies conducted in Ethiopia that examined the spatial pattern and clustering of childhood anemia, undernutrition and under-five mortality. Therefore, this study attempted to fill the knowledge gaps and answer the question "*Is there any evidence of spatial pattern and clustering of childhood undernutrition, childhood anemia, and under-five mortality in the country*?". The finding of the study will help monitor the spatial-based variations in childhood undernutrition, anemia, and under-five mortality. Besides, conducting spatial analysis on these indicators helps local government and development partners, as well as policymakers to design and implement geographic location-specific policies in the country. Furthermore, identifying hotspot areas of under-five mortality, childhood undernutrition, and anemia through spatial analysis could be crucial for the better implementation of location specific interventions.

10.2. Data and Methods

10.2.1. Study Setting

Ethiopia is characterized by enormous diversity (USAID, 2021). The country has extensive altitudinal and geographical variations, ranging from 116 meters below sea level to the peak of 4620 meters above sea level (EBI, 2014). In 2022, the country's population was estimated 123 million with 2.6% annual growth rate, which makes it the second most populous country in Africa (UNDP, 2022). Ethiopia is one of the poorest countries, and agriculture accounts for the majority of employment in the Ethiopian economy, employing over 67% of the labor force and representing over 34% of Gross Domestic Product (IISD/IFPRI, 2022).

In view of improving child survival, the Ethiopian government has adopted several programmatic strategies, including the integrated management of newborn and childhood illness approach, child survival strategy, the national newborn and child development strategy (MOH, 2021). Despite efforts made to enhance child survival through the implementation of strategies for child survival, the access to and utilization of the childhood lifesaving interventions may not be uniform across different geographic areas (FMOH, 2016), and the country is still experiencing wide child survival inequalities by geographic location (FDRE, 2020).

10.2.2. Study Design and Data Source

The spatial analysis used the Ethiopian Demographic and Health Surveys (EDHS) data collected in 2011 and 2016 that provide geographic, demographic, and health information of children below the age of five and their mothers between 15 and 49 years old. The EDHSs are large-scale and cross-sectional surveys conducted in a nationally representative sample of households from eleven regions of Ethiopia. Research participants have provided informed consent before interviews were conducted for demographic health surveys. A two-stage stratified cluster sampling technique was used for both rounds of the EDHS. In the first stage, enumeration areas (EAs) (referred to as clusters) were selected. At this stage, 624 and 645 clusters were selected in the 2011 and 2016 EDHSs, respectively. In the second stage, systematic random sampling was applied to select households (on average 28 households) per selected cluster using sampling frame of the Ethiopian population and housing census conducted in 2007 for both the 2011 and 2016 EDHS. The present analysis employed cluster (ecological) design where data were analyzed at the cluster level (Levin, 2006). The datasets, including shapefiles, were downloaded from the DHS program website (https://dhsprogram.com/data/datasetadmin/index.cfm) after securing online permission. The pooled data, consisting of 22,225 under-five children, was extracted from both the 2011 and 2016 DHS Kids Recode (KR) datasets. Accordingly, the pooled data was linked with the merged 2011 and 2016 DHS Shapefiles, and 596 EA (clusters) were matched to their respective regions accordingly.

10.2.3. Study Variables

Childhood undernutrition, childhood anemia, and under-five mortality were the study variables. Childhood undernutrition was assessed through the Composite Index of Anthropometric Failure

(CIAF) approach and determined using a z-score to categorize under-five children into seven subgroups (Nandy et al., 2005): no failure, wasting only, wasting and underweight, wasting, stunting and underweight, stunting and underweight, stunting only, and underweight only. Based on this classification, childhood undernutrition was recoded into a dummy variable, considered undernourished and assigned a value of 1 if child had any form of anthropometric failure, and 0 if the child had no failure. Childhood anemia was also recoded into a dummy variable where a child was considered to be anemic and assigned a value of 1 if the child had a severe, moderate, or mild anemia level, and 0 if child was not anemic. Under-five mortality was assigned a value of 1 if the child died between 0 and 59 months and 0 if the child was alive at least until the age of 59 months. Finally, all the three (indicators) variables were collapsed by cluster (EA) ID to link with Geographic Coordinate System using EDHS shapefile and ArcGIS.

10.2.4. Data Analysis

Under-five children with missing height or length, weight, and unknown responses (consisting of 3%) were excluded from the analysis. In addition, under-six-months of age infants were excluded from childhood anemia analysis. Descriptive statistics was used to describe the regional distribution of childhood undernutrition, anemia and under-five mortality for the pooled data. Spatial analysis was employed to explore the spatial patterns and spatial clustering of the three child survival indicators and to further detect hot and cold spots across the country. Spatial autocorrelation was employed to examine the spatial patterns and clustering of the three child survival indicators with lens of Tobler's first law of geography, which states that everything is related to everything else, but nearby things are more related than distant things (Tobler, 1970). Accordingly, Moran’s I (Moran, 1948) and Getis-Ord Gi* (Getis & Ord, 1992) statistics were employed to examine spatial patterns, and clustering of the variables, and generate hot spot and cold spot areas across the country. Accordingly, ArcGIS was used to conduct the spatial autocorrelation of the three outcome variables and determine if they are spatially clustered, dispersed, or random (Kondo, 2021). After confirming the presence of a spatial pattern of the study variables, high and low-clusters were also identified through Getis Ord General G statistics (Getis & Ord, 1992). Finally, a hot and cold spot analysis (Kondo, 2016) was conducted using Getis Ord Gi* statistics to identify the potential hot-spot and cold-spot areas of childhood undernutrition, childhood anemia, and under-five mortality across the country. All statistical procedures, including data processing, and spatial analysis, were conducted based on weighted data using STATA version 17 and ArcGIS version 10.8.

10.3. Results

10.3.1. Regional Proportion of the Study Participants

Table 10-1 shows the regional proportion of childhood undernutrition, childhood anemia, and under-five mortality for the pooled data. The Table shows that about 49% and 55% of under-five children were undernourished and anemic. Relatively, the highest and lowest proportion of undernourished children were found in Afar (61.6%) and Addis Ababa (21.1%), respectively. Comparatively, the highest proportion of anemic children were found in Somali (77.9%), followed by the Afar (76.1%) regional state. The smallest proportion (39%) of anemic children was reported in the Amhara regional state. On average, 1 in 14 under-five children was reported to have died in the country during the survey period.

Table 10-1: Regional proportion of under-five children by region and indicator type, Ethiopia 2011, 2016.

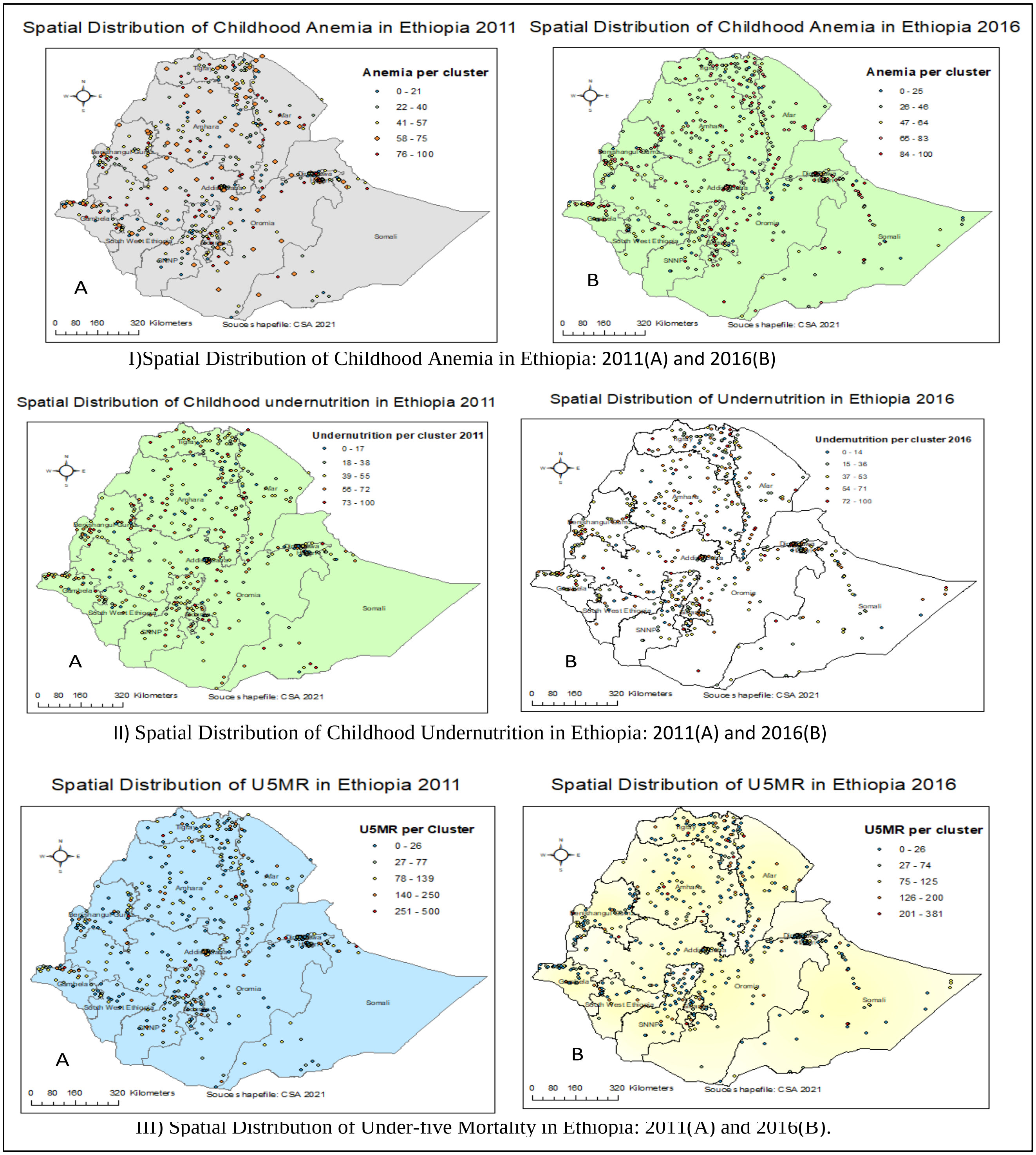
Regional States	**Childhood Undernutrition (N= 18,325)**		**Childhood Anemia (N=16, 234)**		**Under-five mortality (N=22,225)**	
	Nourished N (%)	Undernourished N (%)	Not Anemic N (%)	Anemic N (%)	Alive N (%)	Died N (%)
Addis Ababa	565(78.9)	151(21.1)	324(58.4)	231(41.6)	828(96.7)	28(3.3)
Afar	657(38.4)	1052(61.6)	371(23.9)	1179(76.1)	1999(91,4)	187(8.6)
Amhara	832(42.9)	1108(57.1)	1074(60.9)	688(39.1)	2123(93.8)	140(6.2)
Benishangul	710(45.7)	843(54.3)	769(54.7)	638(45.3)	1737(91.7)	158(8.3)
Dire Dawa	542(54.2)	458(45.2)	266(31.3)	583(68.7)	1174(94.7)	66(5.3)
Gambella	762(61.8)	470(38.2)	491(45.3)	593(54.7)	1448(92.8)	113(7.2)
Harari	585(60.7)	379(39.3)	317(39.7)	482(60.3)	1063(93.4)	75(6.6)
Oromia	1522(53.0)	1351(47.0)	1059(41.5)	1492(58.5)	3121(93.7)	210(6.3)
SNNPR	1309(53.5)	1137(46.5)	1268(56.9)	960(43.1)	2688(93.3)	193(6.7)
Somali	1020(53.9)	871(46.1)	367(22.1)	1294(77.9)	2348(92.9)	179(7.1)
Tigray	921(46.0)	1080(54.0)	986(55.2)	802(44.8)	2105(94.6)	120(5.4)
Total	**9425(51.4)**	**8900(48.6)**	**7192(44.9)**	**8942(55.1)**	**20747(93.3)**	**1478(6.7)**

Source: The 2011 and 2016 Ethiopia Demographic and Health surveys.

10.3.2. Results of Spatial Analysis

10.3.2.1. Spatial distribution of anemia, undernutrition and under-five mortality

Figure 10-1 illustrates the spatial distribution of the prevalence childhood anemia, childhood undernutrition, and under-five mortality rate per sampled cluster in Ethiopia during the study period.



I)Spatial Distribution of Childhood Anemia in Ethiopia: 2011(A) and 2016(B)

II) Spatial Distribution of Childhood Undernutrition in Ethiopia: 2011(A) and 2016(B)

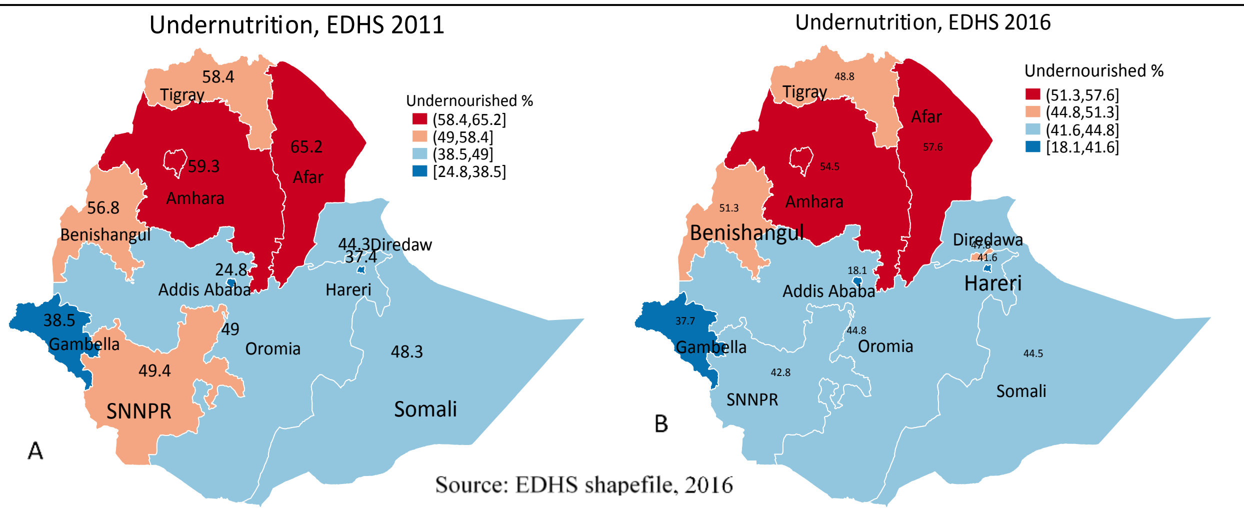
III) Spatial Distribution of Under-five Mortality in Ethiopia: 2011(A) and 2016(B).

Figure 10-1: Spatial distribution of childhood anemia (I), undernutrition (II), and under-five mortality (III) in Ethiopia.

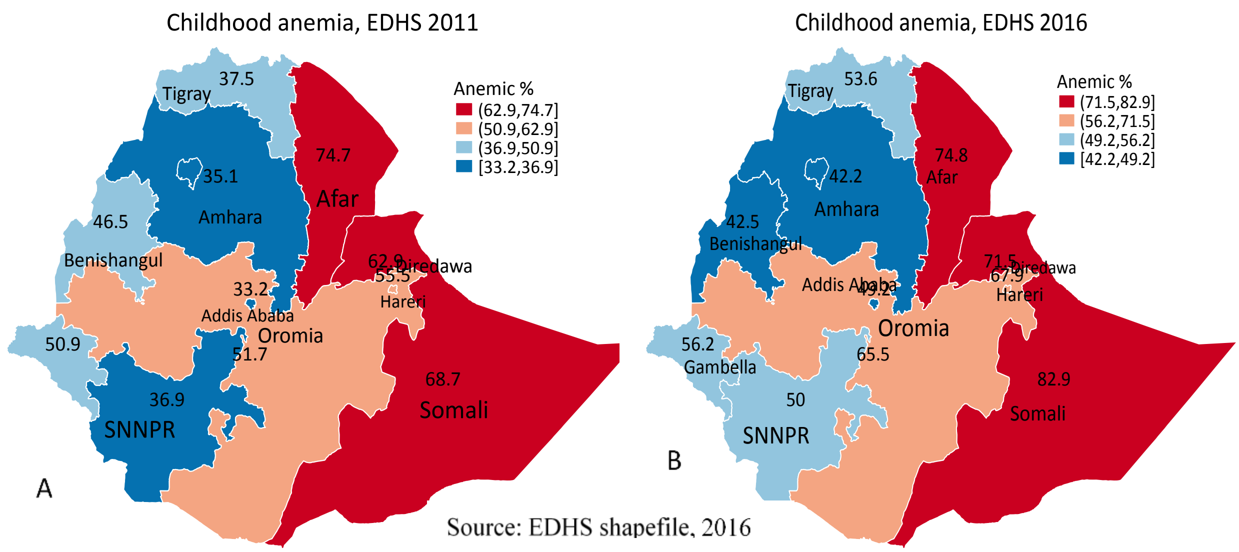
Figure 10-2 depicts the regional average prevalence of childhood undernutrition across the old eleven regional states of Ethiopia by survey year. As shown in Figure 1(I-A), Amhara and Afar regional states of the country had the largest prevalence (more than 59%) of childhood undernutrition in 2011. In the same year, three regional states (Beneshangul-Gumz, Harari, and Addis Ababa City Administration) had the lowest prevalence (less than 39%) of childhood undernutrition in the country (Figure 10-2, I-A). In 2016, the Amhara and Afar regional states had the largest prevalence (more than 51%) of childhood undernutrition, while the Beneshangul-Gumuz and Harari regional states and Addis Ababa City Administration had lowest proportion of undernourished under-five children (Figure 10-2, I-B).

As seen from Figure 10-2 (II-A and II-B), the Eastern part of the country, particularly Afar and Somali regional states and Dire Dawa City Administration had the highest prevalence of childhood anemia in 2011 (more than 62%), and 2016 (more than 71%), whereas the Amhara region and Addis Ababa City Administration reported the lowest prevalence of childhood anemia in both 2011 and 2016. The spatial discrepancy shows that the eastern part of the country (especially, Afar and Somali regional states and Dire Dawa) was markedly affected by childhood anemia as compared to other parts of the country during the study period (Figures 10-2, II- A and B).

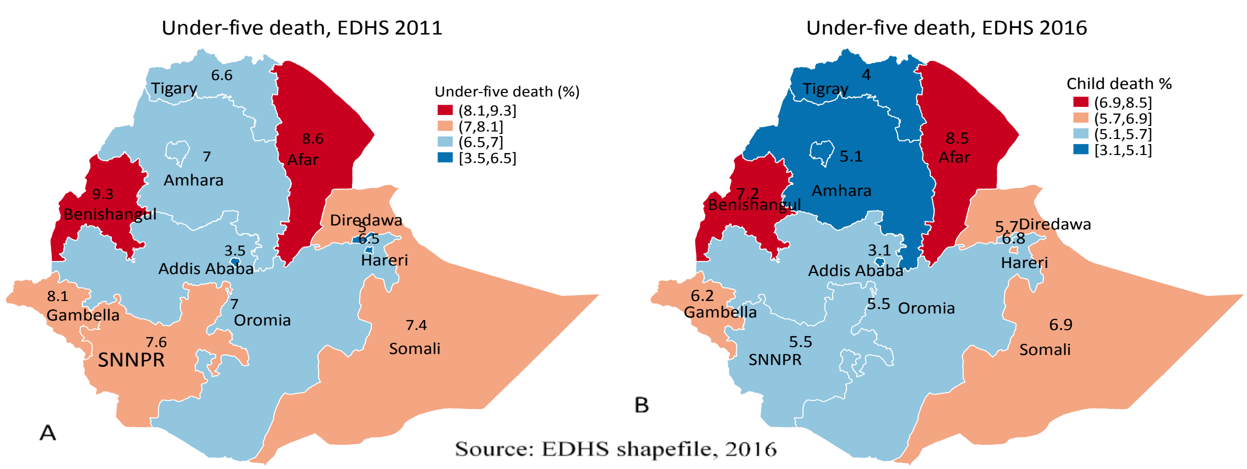
Figure 10-2 (III) presents the regional average proportion of under-five children deaths across the old eleven regional states of Ethiopia by survey year. Figure 10-3 shows that the eastern (Afar) and western (Benishangul-gumuz) regional states of the country had the largest proportion of under-five deaths in both 2011(more than 8%) and 2016 (more than 7%), while Addis Ababa city administration had the lowest proportion (3.5 and 3.1%) of under-five deaths during the study period (Figures 10-2, I, III- A and B).



I) Regional prevalence of undernourished children: 2011(A) and 2016(B)



II) Regional average prevalence of childhood anemia children: 2011(A) and 2016(B).



III) Regional average proportion (%) of under-five deaths: 2011(A) and 2016(B).

Figure 10-2: Prevalence of Child Survival Indicators in Ethiopia: Undernutrition (i), Anemia (ii) and U5M (iii).

10.3.2.2. Spatial Patterns of Undernutrition, Anemia and Under-five Mortality

Figure 10-3 shows the Global Moran's I spatial autocorrelation of childhood undernutrition in Ethiopia. Based on the EDHS 2011 data, Global Moran's I statistics result showed that childhood undernutrition had statistically significant positive spatial autocorrelation (MI=0.026, p=0.00). The Z-score of 18.37 also indicated a clustered pattern (Figure 3, A). Similarly using EDHS 2016 data, Global Moran's I statistics results also revealed that childhood undernutrition had statistically significant positive spatial autocorrelation (MI=0.024, p=0.00). In addition, the z-score of 18.52 also indicated a cluster pattern of childhood in 2016 (Figure 10-3, B).

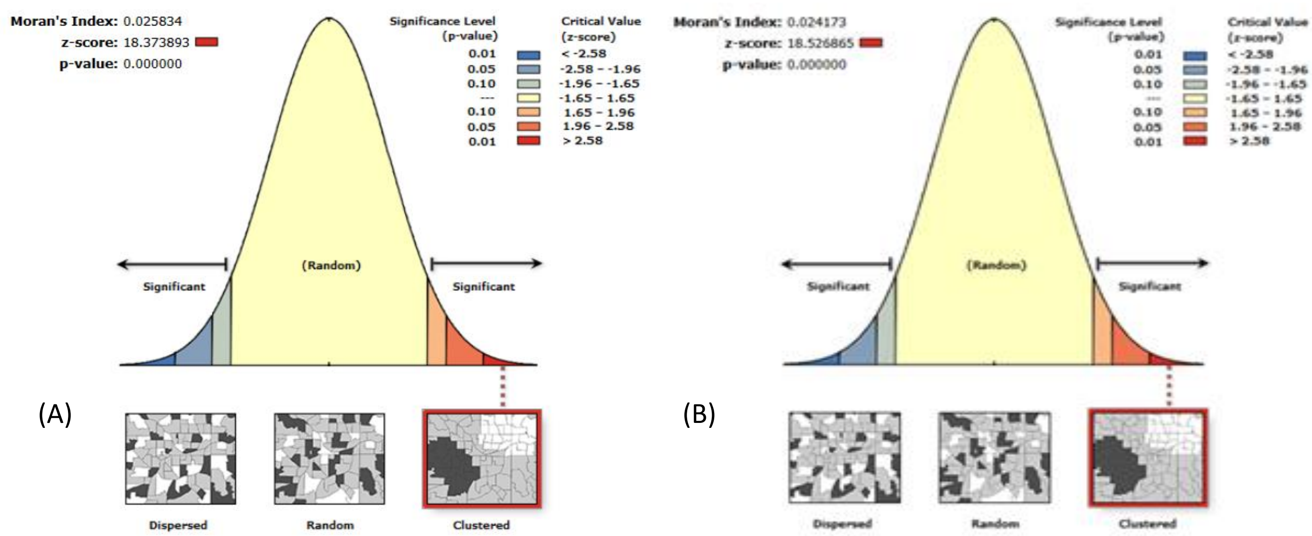


Figure 10-3: Spatial Autocorrelation of Childhood Undernutrition in Ethiopia: (A)2011, (B) 2016.

Figure 10-4 depicts the Global Moran's I spatial autocorrelation of childhood anemia in Ethiopia. According to EDHS's 2011 and 2016 data, the Global Moran's I statistics results showed that childhood anemia had statistically significant positive spatial autocorrelation (MI=0.032, p=0.00, MI=0.029, p=0.00, respectively). The Z-score of 23.01 and 22.45 also indicated a clustered pattern of childhood anemia in 2011 and 2016, respectively (Figure 10-4, A and B).

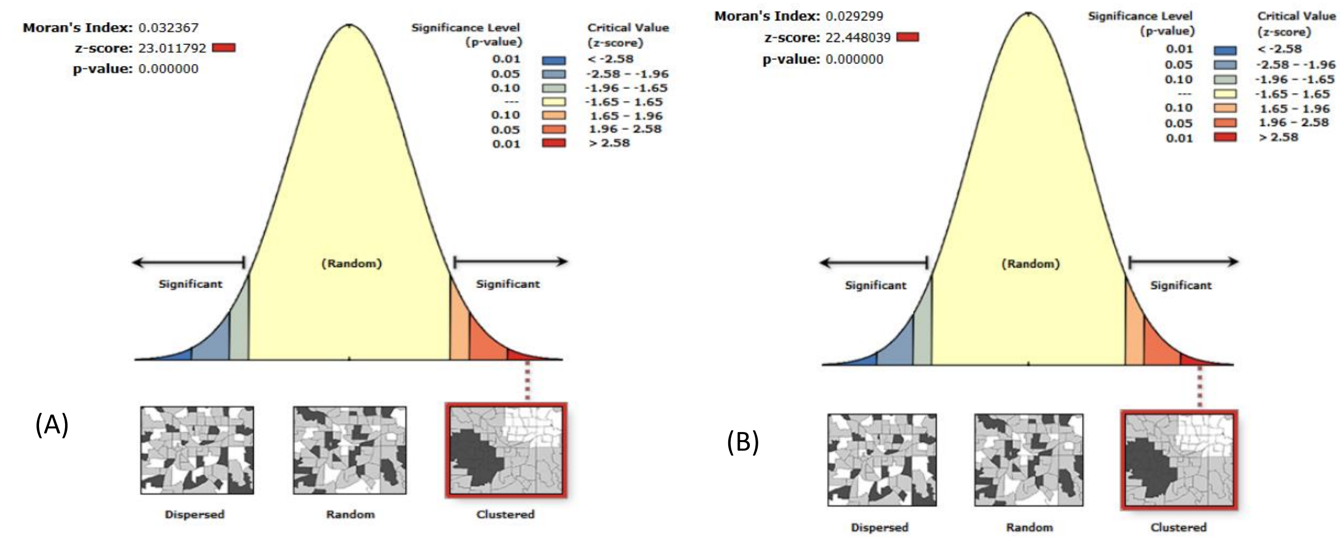


Figure 10-4: Global Autocorrelation of Childhood Anemia in Ethiopia: (A)2011, (B) 2016.

Figure 10-5 shows the Global Moran's I spatial autocorrelation of Under-five mortality in Ethiopia. Global Moran's I statistics results showed that under-five mortality had statistically significant positive spatial autocorrelation (MI=0.01, p=0.00; MI=0.01, p=0.00, respectively), and a clustered pattern with the Z-score value of 3.9 and 6.56, respectively, in 2011 and 2016 (Figure 10-5, A and B).

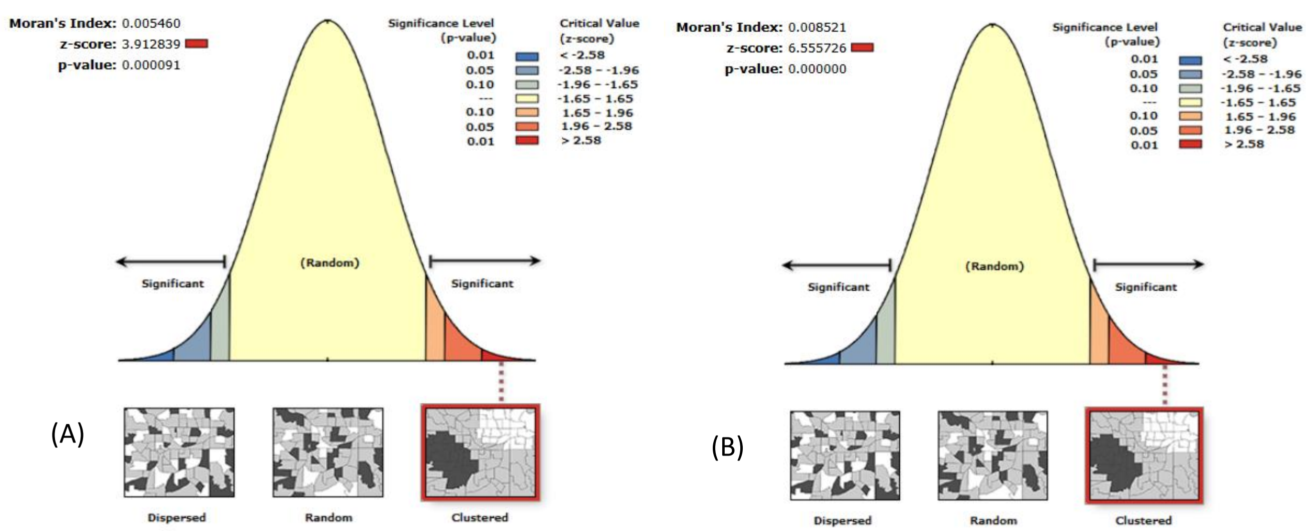


Figure 10-5: Spatial Autocorrelation of Under-five Mortality in Ethiopia: (A)2011, (B)2016.

The Getis Ord General G statistics results also indicated that childhood undermatron, childhood anemia and under-five mortality had high-clusters in 2011 and 2016 (Figure 10-6, I, II, III).

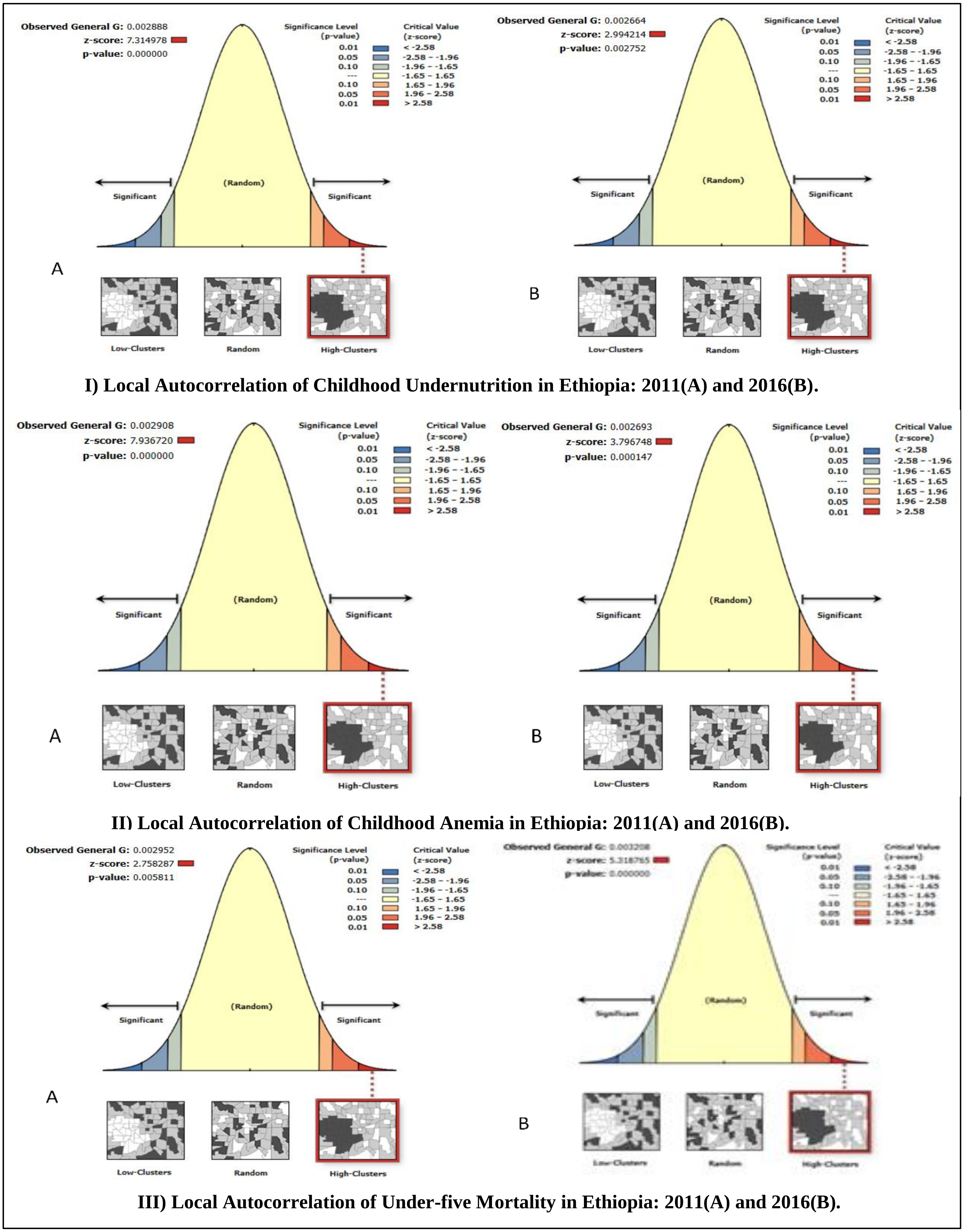


Figure 10-6: Local Autocorrelation of Childhood Undernutrition (I), Anemia (II), and U5M (III) in Ethiopia.

10.3.2.3. Results of Hotspot Analysis

Figure 10-7 shows the hotspot areas of childhood undernutrition, anemia and under-five mortality in Ethiopia in 2011 and 2016. Within 500 meters radius, the spatial clustering of childhood anemia, undernutrition and under-five mortality was consistently observed within and around Addis Ababa, and Dire Dawa city administrations and Harari and Somali (northern part) regional states in both 2011 and 2016 surveys (Figure 10-7).

10.4. Discussion

The purpose of this analysis was to examine the spatial pattern and clustering of childhood undernutrition, childhood anemia, and under-five mortality in Ethiopia using 2011 and 2016 EDHS data. The spatial variations of the child survival indicators (childhood undernutrition, anemia and under-five mortality) were non-random (with p-value <0.0001) across the country, which is consistent with other studies conducted in Ethiopia (Alemu et al., 2016; Jember et al., 2021; Liyew et al., 2021). Our analysis also reveals that there were statistically significant high-clusters of childhood undernutrition, anemia and under-five mortality in Ethiopia during the study period.

Although the most nearby spatial clusters (within 500 meter radius) were found in and around the urbanized settings (Addis Ababa, Dire Dawa, and Harari) of the country, the regional prevalence clearly showed that the east- and west-northern (Afar and Amhara regional states) parts of the country were markedly affected by childhood undernutrition during the study periods (Figure 10-2, III-A and B), which is similar with the study conducted by Alemu and colleagues (Alemu et al., 2016). In addition, the eastern (particularly Afar and Somali regional states) part of the country was prominently affected by childhood anemia (Jember et al., 2021).

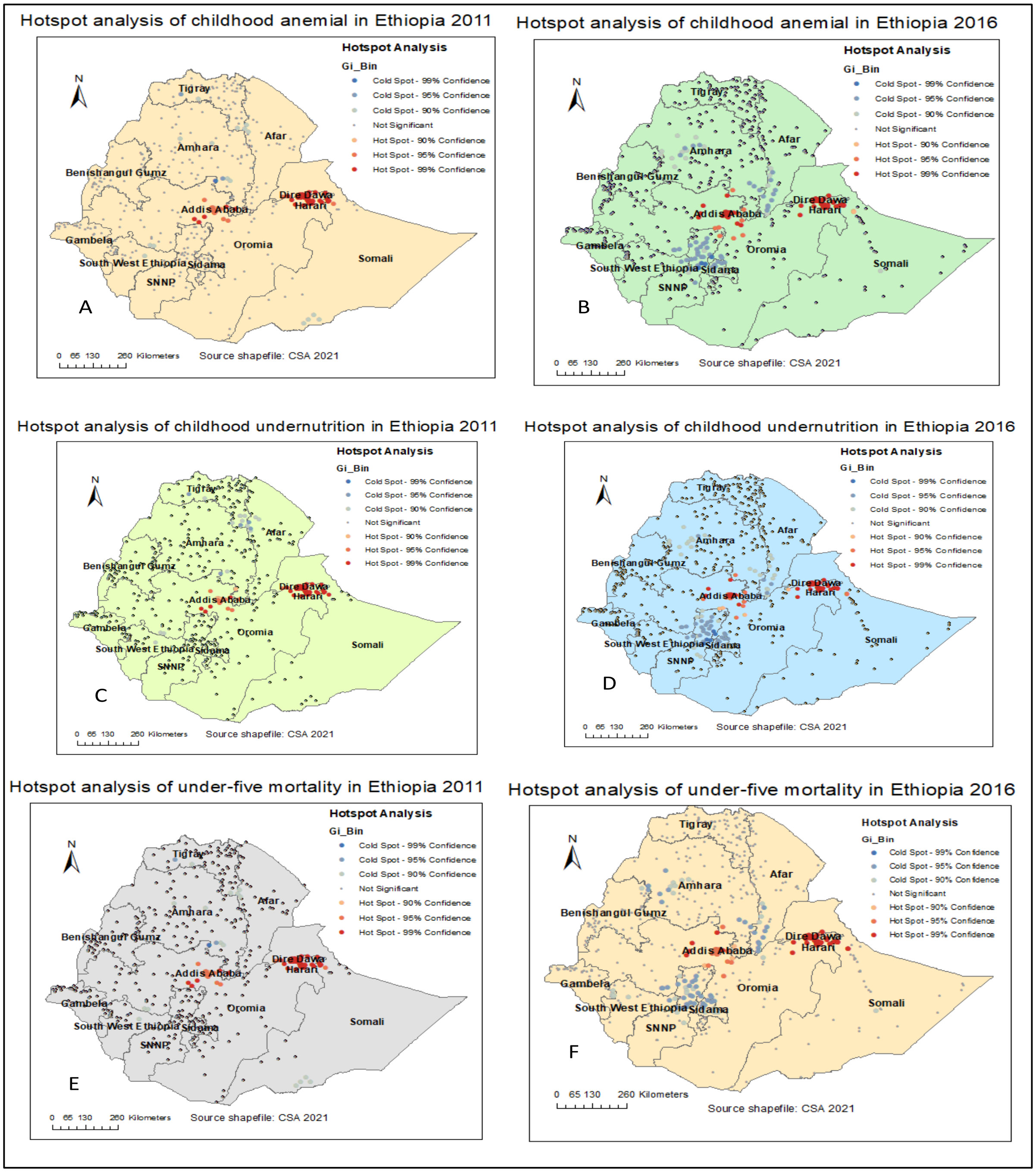


Figure 10-7: Hotspot distribution (500km) of childhood undernutrition, anemia, and U5M in Ethiopia.

Moreover, the western (Benishangul-Gumuz regional state) and the north-eastern (Afar regional state) parts of the country were noticeably affected by under-five mortality. This result is supported by findings in the country (Liyew et al., 2021). The possible reason might be both regions could have remote areas inaccessible for child health care, and water and sanitation services along with malaria prevalence. Worryingly, the Afar regional state was found to have a high prevalence of childhood undernutrition and anemia and under-five mortality during the study period. This might be due to the regional differences in socioeconomic status, access to resources, level of education, cultural and feeding practices in Afar region. Furthermore, the access to and utilization of the child health care services may not be uniform across remote geographic areas in the region.

Strengths and Limitations

The present study has explored the spatial clustering of childhood undernutrition, anemia and under-five mortality based on nationally representative data. The findings will undoubtfully help health care administrators to design effective spatial based program interventions to reduce childhood anemia, childhood undernutrition and under-five mortality in the country. However, this study is not free from limitations. First, as the study used cross-sectional data collected at a point in time, it was impossible to establish causal effect relationship. Second, due to limited scope, the contextual and other important variables were not included in the analysis of the study.

10.5. Conclusion

Given the above findings, the present study underscores the importance of spatial location specific child survival interventions targeted to reduce childhood anemia, undernutrition and under-five mortality. Therefore, child survival programs tailored to geographic location risk factors connected with childhood anemia, undernutrition and under-five mortality would be more efficient and effective in Ethiopia. A further study on the causes of childhood undernutrition, anemia and under-five mortality should be conducted in the identified regions, or parts of the country.

CHAPTER ELEVEN

Major Findings, Policy Implications and Future Work

The preceding chapters of this study have delved into a comprehensive examination of factors influencing childhood undernutrition, anemia, and under-five mortality based on repeated cross-sectional surveys. While shedding light on critical aspects of child survival, it is imperative to highlight the major findings, policy implications, and avenues for future research. This synthesis aims to distill key insights, translate them into actionable policy considerations, and chart a course for future investigations in this vital domain.

11.1. Major Findings

The study began with exploring the relative importance of the key drivers of inequality in child survival. The dominance analysis revealed that maternal education, place of residence and household wealth status were the three dominant drivers of childhood undernutrition inequality. Dominance analysis also identified administrative region as the most dominant driver of inequalities in childhood anemia. Maternal education was also found as a key dominant driver for the existing inequalities in under-five mortality in the country. The findings from the dominance analysis further highlighted the importance of interventions and policies that enhance socioeconomic and livelihood of uneducated, the poor and rural population groups to reduce inequalities in childhood undernutrition, with special emphasis on regional variations for accelerated reduction in childhood anemia. In addition, the study finding also emphasized the importance of robust and influencing policies and interventions for reducing inequalities in child mortality and improving the overall child survival through addressing urban-rural and maternal education gaps at community and individual levels.

Secondly, the present study showed that the level of inequality in childhood undernutrition was the highest with children from rural areas, poor households and uneducated mothers; whereas the inequality with children born from urban areas, and non-poor households and educated mothers was minimal. The finding also showed that childhood undernutrition was more concentrated among lower socioeconomic population groups. This might be explained by different reasons.

First, children residing in rural areas may not have better access to health care service and improved water. Second, children residing in poor households might be affected by food insecurity. Third, children from uneducated mothers might have lower access to feeding practice and healthcare. Fourth, the poorest population groups may not afford to purchase various quantities and qualities of food to feed their children and access to health care services. The overall absolute socioeconomic inequality in childhood undernutrition has declined by 9.72 from 2000 to 2019. The decline was largely attributed to narrowed gap in maternal education during the past two decades. Such decline could be explained by the nutritional and health related policy commitment taken by the Government of Ethiopia in the past decades.

Thirdly, the findings of Theil index analysis indicated about 13.14% reduction of the relative regional inequality in childhood anemia from 0.620 in 2005 to 0.548 in 2016, which could be due to continued implementation of national and international commitments in the country. The overall relative inequalities in childhood anemia were largely explained by within region inequalities with the highest childhood anemia in Somali (78.68%) followed by Afar region (72.76%) while the lowest childhood anemia was in Amhara (41.01%). This indicates that the existence of the highest burden of childhood anemia in emerging regions as compared to non-emerging regions (i.e., established regions and urban regions). This might be due to the fact that Somali and Afar regions are pastoral, drought and malaria-prone regions. Decomposition analysis also revealed that nearly half (47.12%) of the regional inequalities was due to difference in observed characteristic effects, which could be significantly explained household asset-based wealth index, maternal anemia and maternal employment.

Fourthly, the residential inequalities in child mortality investigation confirmed the existence of significant higher child mortality in rural areas than in urban areas which might be due to difference in access and distance to public health service, population living standards, health conditions, child health care seeking behavior and exposure to media by place of residence in Ethiopia. The largest part of the rural-urban inequality in child mortality was attributable to individual, household and community level factors. Accordingly, substantial efforts are needed to reduce residential inequalities in child mortality with special focus on child's birth size, birth order, sanitation facility, and socioeconomic status of urban- and rural-poor population subgroups of the country.

Fifthly, although maternal education's significance varies across chapters due to differences in focus, data sources, and analysis methods, it was found to be the key driver for inequality in under-five mortality. Under-five children born from uneducated mothers were found to have a greater likelihood of mortality than those born from educated mothers, which indicates that the maternal education could help reduce under-five mortality by adopting greater access to child healthcare, including use of child vaccination, and safe water. The multivariate decomposition analysis revealed that about one-third (31%) of the maternal education-based inequalities in under-five mortality could be explained by observed characteristic effects. In particular, the household size could have an impact to widen maternal education-based inequalities in under-five mortality by 46.93%. The decomposition analysis also further witnessed that the overall absolute inequalities in under-five mortality declined by 0.14 in the period of 2000-2005 and 0.32 during the period between 2000 and 2016, indicating about 56.25 percent of change. This study also suggested that about 43.12% of the decline in under-five mortality would be attributed to narrowed gap in maternal education during the survey period in the country.

Sixth, Population Attributable Fractions (PAFs) analyses of risk factors of childhood anemia confirmed that controlling five modifiable risk factors (i.e., presence large household size (5+), and being poor household, born from anemic and unemployment mothers, and breastfed for less than six months) could possibly prevent about 39% of the reported burden of childhood anemia at the population level. The PAFs analysis also revealed that nearly half (46%) of the reported childhood undernutrition could potentially be reduced by removing these three modifiable risk factors (unimproved toilet facility, solid cooking fuel, and home delivery) at the population level. This shows that using improved sanitation facility, clean cooking fuel and health facility contribute to prevent about 46% of childhood undernutrition at population level. Similarly, about half (51.3%) of reported under-five mortality could potentially be averted by controlling number children ever born to mothers at population level.

Finally, the spatial variations of the child survival indicators (childhood undernutrition, anemia and under-five mortality) were found to be non-random (p-value <0.0001) across the country. In addition, spatial analysis results also confirmed that there were statistically significant high-clusters of childhood undernutrition, anemia and under-five mortality in the country during the study period. It is crucial to note that the Afar regional state had a high prevalence of childhood undernutrition and anemia and under-five mortality during the study period. One of the potential reasons might be due to variation in socioeconomic status, access to resources, level of education, cultural and feeding practices in Afar region. Another reason could be that the access to and utilization of the child health care services may not be uniform across remote geographic areas in this region.

11.2. Policy Implications

In this study, geographic region and place of residence (community level), households' socioeconomic status (household level), and maternal education (individual level) were found to be the most dominant drivers of inequality in child survival in the country. For example, childhood undernutrition was largely concentrated among low socioeconomic status population groups. In addition, household asset-based wealth index had statistically significant contribution to explain the regional inequalities in childhood anemia over the study period. Moreover, maternal education had substantial impact on inequalities in under-five mortality. This study suggests the importance of understanding the community, household and individual levels influence in addressing inequalities in child survival. Improving the socioeconomic status of the poorest households, prioritizing emerging regions and rural areas with the highest needs, and enhancing maternal education status would significantly reduce child survival inequalities in the country.

Based on the findings provided, here are some policy implications for Ethiopia:

- In Ethiopia, while progress has been made in improving primary education access, disparities persist, especially in rural and marginalized areas. These disparities are linked to higher rates of childhood undernutrition, anemia and under-five mortality. Therefore, building on existing education policies, the government can enhance girls' education and adult literacy programs, particularly in rural regions with high child survival inequalities. Integrating nutrition education into school curricula and vocational training programs can empower women economically and improve child survival

- ❖ Ethiopia has implemented community health extension and nutrition programs to enhance child survival, but challenges remain in impacting childhood undernutrition. Thus, strengthening primary healthcare services and existing programs in underserved regions, especially in emerging regions, is crucial. Integrating nutrition programs into existing health services can improve access to healthcare and nutrition services for emerging regions by ensuring the proper implementation of the recently revised (2016) National Nutrition Program at all levels.
- ❖ Regional variations in healthcare infrastructure and cultural practices contribute to disparities in childhood anemia. Regions like Afar and Somali face unique challenges due to nomadic lifestyles and limited access to services. And hence, tailoring health and nutrition interventions to address regional needs is essential. Implementing culturally sensitive programs and mobile health units can bridge the gap in healthcare access for nomadic communities and other marginalized groups.
- ❖ Rural-urban disparities in healthcare access and living conditions impact child mortality rates in Ethiopia, highlighting the need for targeted interventions in rural areas. Therefore, strengthening the Health Extension Program to provide essential healthcare services in rural communities and improving sanitation facilities can help reduce residential inequalities in child mortality. Community-based programs promoting hygiene practices and clean water sources are essential in addressing these disparities.

- ❖ Maternal education significantly influences under-five mortality in Ethiopia, with higher education levels linked to lower likelihood of under-five mortality. Integrating maternal and child health education into school curricula and adult literacy programs can empower women and improve child survival. Incentivizing rural girls' education and supporting women's economic empowerment through skills training programs can further reduce under-five mortality rates.
- ❖ Modifiable risk factors such as household size, socioeconomic status, and breastfeeding practices impact child survival in the country, necessitating a multi-sectoral approach. And hence, strengthening social protection programs to address poverty and food insecurity, promoting optimal breastfeeding practices through behavior change communication campaigns, and improving household sanitation and cooking practices can mitigate modifiable risk factors and improve child survival.
- ❖ Spatial analysis reveals clustering of child survival indicators in specific regions, highlighting the need for targeted interventions in high-burden areas. Hence, leveraging the Health Extension Program to deliver targeted interventions in high-cluster and hotspot areas and enhancing monitoring and evaluation systems to track progress are essential. Adapting interventions based on spatial variations in child survival indicators can effectively reduce child survival disparities across different regions in the country.

11.3. Future Work

Building on the limitations identified in this study, several avenues for future work emerge, each aimed at addressing gaps, enhancing methodologies, and providing a more nuanced understanding of child survival. The following are recommendations for future research:

- Conduct longitudinal studies to establish cause-effect relationships over time. This will allow for a more in-depth exploration of the temporal dynamics of inequalities in childhood undernutrition, anemia, and under-five mortality. Longitudinal designs would help capture changes and trends, contributing to a more robust analysis, including causal inference models.
- Engage in a more comprehensive examination of key drivers of inequalities in childhood undernutrition, anemia and under-five mortality, beyond the internationally accepted ones. This may involve a thorough literature review and empirical investigations into contextual, cultural, and environmental factors.
- Consider some of unexplored determinants such as household food security status, maternal nutrition status, appropriate dietary feeding practices, affordability and accessibility to care, and distance to the nearest health facility. This will provide a more holistic understanding of the factors impacting child survival in the country.
- Foster interdisciplinary collaborations with experts from diverse fields, including nutrition, public health, epidemiology, sociology, and geography. Integrating multiple perspectives would lead to a more comprehensive analysis and a deeper understanding of the intricate dynamics of child survival inequalities in the country.

- ❖ Focus on evaluating the impact of child survival specific policies and programs on childhood health outcomes. This could help inform policymakers about the effectiveness of interventions, guiding the refinement and adaptation of existing programs.
- ❖ Expand the scope of spatial analysis by including contextual variables. This could involve incorporating geographic information system (GIS) data, climate variables, or other relevant contextual factors to enhance the spatial understanding of child survival inequalities.
- ❖ Employ mixed-methods research, combining both quantitative and qualitative approaches. This integrated methodology can offer a more comprehensive understanding of the complex determinants of child survival.

Reference

Abraha, H. E., Belachew, A. B., Ebrahim, M. M., Tequare, M. H., Adhana, M. T., & Assefa, N. E. (2020). Magnitude, trend, and causes of under-five mortality from Kilite-Awlaelo health demographic surveillance database, northern Ethiopia, 2009-2017. *BMC Public Health*, *20*(1). https://doi.org/10.1186/s12889-020-09554-z

Adedokun, S. T., & Yaya, S. (2021). Factors associated with adverse nutritional status of children in sub-Saharan Africa: Evidence from the Demographic and Health Surveys from 31 countries. *Maternal and Child Nutrition*, *17*(3), 1–10. https://doi.org/10.1111/mcn.13198

Adel Hussein Elduma. (2018). Equality Analysis of Main Health Indicators among Children under 5 Years in Uganda. *Ethiop J Health Sci.*, *29(2)*, 215. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6460442/

Adeyinka, D. A., Muhajarine, N., Petrucka, P., & Isaac, E. W. (2020). Inequities in child survival in Nigerian communities during the Sustainable Development Goal era: insights from analysis of 2016/2017 Multiple Indicator Cluster Survey. *BMC Public Health*, *20*(1). https://doi.org/10.1186/s12889-020-09672-8

Adeyinka, D. A., Olakunde, B. O., & Muhajarine, N. (2019). Evidence of health inequity in child survival: spatial and Bayesian network analyses of stillbirth rates in 194 countries. *Scientific Reports*, *9*(1), 1–11. https://doi.org/10.1038/s41598-019-56326-w

Agbadi, P., Agbaglo, E., Tetteh, J. K., Adu, C., Ameyaw, E. K., & Nutor, J. J. (2021). Trends in under-five mortality rate disaggregated across five inequality dimensions in Ghana between 1993 and 2014. *Public Health*, *196*, 95–100. https://doi.org/10.1016/j.puhe.2021.04.024

Agho, K. E., Akombi, B. J., Ferdous, A. J., Mbugua, I., & Kamara, J. K. (2019). Childhood undernutrition in three disadvantaged East African Districts: A multinomial analysis. *BMC Pediatrics*, *19*(1), 1–11. https://doi.org/10.1186/s12887-019-1482-y

Aguilera, X., Delgado, I., Icaza, G., Apablaza, M., Villanueva, L., & Castillo-Laborde, C. (2020). Under five and infant mortality in Chile (1990-2016): Trends, disparities, and causes of death. *PLoS ONE*, *15*(9 September), 1–17. https://doi.org/10.1371/journal.pone.0239974

Ahinkorah, B. O., Seidu, A. A., Budu, E., Armah-Ansah, E. K., Agbaglo, E., Adu, C., Hagan, J. E., & Yaya, S. (2020). Proximate, intermediate, and distal predictors of under-five mortality in Chad: analysis of the 2014–15 Chad demographic and health survey data. *BMC Public Health*, *20*(1), 1–12. https://doi.org/10.1186/s12889-020-09869-x

Ahmed, A., Abdulahi, A., & Shab-bidar, S. et al. (2017). Nutritional Status of Under Five Children in Ethiopia : A Systematic Review and Meta-Analysis. *Ethiopian J Health Sci*, *27*(2), 175–188. http://dx.doi.org/10.4314/ejhs.v27i2.10

Ahmed, K. Y., Agho, K. E., Page, A., Arora, A., & Ogbo, F. A. (2021). Mapping geographical differences and examining the determinants of childhood stunting in ethiopia: A bayesian geostatistical analysis. *Nutrients*, *13*(6). https://doi.org/10.3390/nu13062104

Akeju, K. F., Jegede, L. I., Oluyemo, C. A., & Ilori, A. I. (2021). Explaining regional variations in child survival in Nigeria: Evidence from demographic and health survey. *GeoJournal*, *7*. https://doi.org/10.1007/s10708-021-10420-7

Akombi, B. J., Agho, K. E., Renzaho, A. M., Hall, J. J., & Merom, D. R. (2019). Trends in socioeconomic inequalities in child undernutrition: Evidence from Nigeria demographic and health survey (2003 – 2013). *PLoS ONE*, *14*(2), 1–13. https://doi.org/10.1371/journal.pone.0211883

Alao, R., Nur, H., Fivian, E., Shankar, B., Kadiyala, S., & Harris-Fry, H. (2021). Economic inequality in malnutrition: a global systematic review and meta-analysis. *BMJ Global Health*, *6*(12), e006906. https://doi.org/10.1136/bmjgh-2021-006906

Alemu, Z. A., Ahmed, A. A., Yalew, A. W., & Birhanu, B. S. (2016). Non random distribution of child undernutrition in Ethiopia: Spatial analysis from the 2011 Ethiopia demographic and health survey. *International Journal for Equity in Health*, *15*(1), 1–10. https://doi.org/10.1186/s12939-016-0480-z

Alliance. (2022). *Global hunger index: Ethiopia Policy Brief. Alliance 2015 towards the eradication of poverty. April 2022*.

Amegbor, P. M., Borges, S. S., Pysklywec, A., & Sabel, C. E. (2022). Effect of individual, household and regional socioeconomic factors and PM2.5 on anaemia: A cross-sectional study of sub-Saharan African countries. *Spatial and Spatio-Temporal Epidemiology*, *40*(November 2021), 100472. https://doi.org/10.1016/j.sste.2021.100472

Ameyaw, E. K., Kareem, Y. O., Ahinkorah, B. O., Seidu, A. A., & Yaya, S. (2021). Decomposing the rural-urban gap in factors associated with childhood immunisation in sub-Saharan Africa: Evidence from surveys in 23 countries. *BMJ Global Health*, *6*(1). https://doi.org/10.1136/bmjgh-2020-003773

Amir-Ud-Din, R., Fawad, S., Naz, L., Zafar, S., Kumar, R., & Pongpanich, S. (2022). Nutritional inequalities among under-five children: a geospatial analysis of hotspots and cold spots in 73 low- and middle-income countries. *International Journal for Equity in Health*, *21*(1), 135. https://doi.org/10.1186/s12939-022-01733-1

Angdembe, M. R., Dulal, B. P., Bhattarai, K., & Karn, S. (2019). Trends and predictors of inequality in childhood stunting in Nepal from 1996 to 2016. *International Journal for Equity in Health*, *18*(42), 1–17. https://doi.org/10.1186/s12939-019-0944-z

Antai, D., & Moradi, T. (2010). Urban area disadvantage and under-5 mortality in Nigeria: The effect of rapid urbanization. *Environmental Health Perspectives*, *118*(6), 877–883. https://doi.org/10.1289/ehp.0901306

Anteneh, Z. A., & Geertruyden, J. P. Van. (2021). Spatial variations and determinants of anemia among under-five children in Ethiopia, EDHS 2005–2016. *PLoS ONE*, *16*(4 April), 1–24. https://doi.org/10.1371/journal.pone.0249412

Argawu, A. S., & Mekebo, G. G. (2022). Risk factors of under-five mortality in Ethiopia using count data regression models, 2021. *Annals of Medicine and Surgery*, *82*(July), 104764. https://doi.org/10.1016/j.amsu.2022.104764

Assaf, S., & Pullum, T. (2016). Levels and trends in maternal and child health disparities by wealth and region in eleven countries with DHS surveys. *DHS Comparative Reports*, *42*, xv-pp. http://dhsprogram.com/publications/publication-CR42-Comparative-Reports.cfm

Asuman, D., Ackah, C. G., Fenny, A. P., & Agyire-Tettey, F. (2020). Assessing socioeconomic inequalities in the reduction of child stunting in sub-Saharan Africa. *Journal of Public Health (Germany)*, *28*(5), 563–573. https://doi.org/10.1007/s10389-019-01068-2

Ayele, B. A., Abebaw Tiruneh, S., Azanaw, M. M., Shimels Hailemeskel, H., Akalu, Y., & Ayele, A. A. (2022). Determinants of under-five mortality in Ethiopia using the recent 2019 Ethiopian demographic and health survey data: nested shared frailty survival analysis. *Archives of Public Health*, *80*(1), 1–8. https://doi.org/10.1186/s13690-022-00896-1

Azen, R., & Traxel, N. (2009). Using dominance analysis to determine predictor importance in logistic regression. *Journal of Educational and Behavioral Statistics*, *34*(3), 319–347.

https://doi.org/10.3102/1076998609332754

Bado, A. R., & Susuman, A. S. (2016). Women's education and health inequalities in under-five mortality in selected sub-saharan African countries, 1990-2015. *PLoS ONE*, *11*(7). https://doi.org/10.1371/journal.pone.0159186

Balaj, M., York, H. W., Sripada, K., Besnier, E., Vonen, H. D., Aravkin, A., Friedman, J., Griswold, M., Jensen, M. R., Mohammad, T., Mullany, E. C., Solhaug, S., Sorensen, R., Stonkute, D., Tallaksen, A., Whisnant, J., Zheng, P., Gakidou, E., & Eikemo, T. A. (2021). Parental education and inequalities in child mortality: a global systematic review and meta-analysis. *The Lancet*, *398*(10300), 608–620. https://doi.org/10.1016/S0140-6736(21)00534-1

Balluerka, N., Gorostiaga, A., Gómez-Benito, J., & Hidalgo, M. D. (2010). Use of multilevel logistic regression to identify the causes of differential item functioning. *Psicothema*, *22*(4), 1018–1025. http://www.ncbi.nlm.nih.gov/pubmed/21044547

Baranwal, A., Baranwal, A., & Roy, N. (2014). Association of household environment and prevalence of anemia among children under-5 in India. *Frontiers in Public Health*, *2*(OCT), 1–7. https://doi.org/10.3389/fpubh.2014.00196

Bareke, L., Agezew, B. H., Dedho, N. H., & Hailu, A. (2022). *Education Inequalities in Ethiopia : A macro-level Analysis and its Policy Implications*. *June*. https://doi.org/10.20944/preprints202206.0341.v1

Bekele, T., Rawstorne, P., & Rahman, B. (2021). Trends in child growth failure among children under five years of age in Ethiopia: Evidence from the 2000 to 2016 Demographic and Health Surveys. *PLoS ONE*, *16*(8 August). https://doi.org/10.1371/journal.pone.0254768

Berhane, G., Dereje, M., Hoddinott, J., Nisrane, F., Tadesse, F., Seyoum, A., Worku, I., & Yohannes, Y. (2013). *Ethiopia Strategy Support Program II (ESSP II) EDRI Agricultural Growth Program (AGP) of Ethiopia — BASELINE REPORT 2011 Agricultural Growth Program (AGP) of Ethiopia — Baseline report 2011*. *March*.

Bogale, F., Ararso, D., Woldie, E., Mcdonnell, A., Gebreyohannes, Y., Ababor, S., Ruiz, F., Baker, P., Getachew, T., Mideksa, S., Dagne, T., Solomon, D., Kebede, Z., Hadis, M., & Tollera, G. (2022). *Situational Analysis of Health Technology Assessment in*.

Bras, H., & Mandemakers, J. (2022). Maternal education and sibling inequalities in child nutritional status in Ethiopia. *SSM - Population Health*, *17*(February), 101041. https://doi.org/10.1016/j.ssmph.2022.101041

Brault, M. A., Mwinga, K., Kipp, A. M., Kennedy, S. B., Maimbolwa, M., Moyo, P., Ngure, K., Haley, C. A., & Vermund, S. H. (2020). Measuring child survival for the Millennium Development Goals in Africa: what have we learned and what more is needed to evaluate the Sustainable Development Goals? *Global Health Action*, *13*(1), 0–6. https://doi.org/10.1080/16549716.2020.1732668

Buisman, L. R., Van de Poel, E., O'Donnell, O., & van Doorslaer, E. K. A. (2019). What explains the fall in child stunting in Sub-Saharan Africa? *SSM - Population Health*, *8*(March). https://doi.org/10.1016/j.ssmph.2019.100384

Caruana, E. J., Roman, M., Hernández-Sánchez, J., & Solli, P. (2015). Longitudinal studies. *Journal of Thoracic Disease*, *7*(11), E537–E540. https://doi.org/10.3978/j.issn.2072-1439.2015.10.63

(Central Statistical Agency (CSA) [Ethiopia] and ICF., 2016). *Ethiopia Demographic and Health Survey*. *Addis Ababa, and Rochville, Maryland, USA: CSA and IFC. 2016*.

Cha, S., & Jin, Y. (2020). Have inequalities in all-cause and cause-specific child mortality between countries declined across the world? *International Journal for Equity in Health*, *19*(1), 1–13. https://doi.org/10.1186/s12939-019-1102-3

Chao, F., You, D., Pedersen, J., Hug, L., & Alkema, L. (2018). National and regional under-5 mortality rate by economic status for low-income and middle-income countries: a systematic assessment. *The Lancet Global Health*, *6*(5), e535–e547. https://doi.org/10.1016/S2214-109X(18)30059-7

Chikako, T. U., Seidu, A. A., Hagan, J. E., & Ahinkorah, B. O. (2021). Complex multilevel modelling of the individual, household and regional level variability in predictors of undernutrition among children aged 6–59 months in ethiopia. *Nutrients*, *13*(9). https://doi.org/10.3390/nu13093018

Child Health Task Force. (2023). *Child Survival Action – A Renewed Call to Action to End Preventable Child Deaths*. https://www.childhealthtaskforce.org/sites/default/files/2023-03/Child Survival Action_Feb2023_clean.pdf

Croft, Trevor N., Aileen M. J. Marshall, Courtney K. Allen, et al. (2018). Guide to DHS Statistics. Rockville, Maryland, USA: ICF. *Icf*, *version 2*, 22–51. https://www.dhsprogram.com/pubs/pdf/DHSG1/Guide_to_DHS_Statistics_DHS-7_v2.pdf

Croft, Trevor, N., Aileen, M., Mrshall, J., Courtney, K., & Allen, K. (2018). *Guide to DHS Statistics*. 1–90. https://dhsprogram.com/pubs/pdf/DHSG1/Guide_to_DHS_Statistics_DHS-7.pdf

CSA and UNICEF. (2020). *Faces of Poverty: Studying the Overlap Between Monetary and Multidimensional Child Poverty in Ethiopia UNICEF Ethiopia i Faces of poverty: studying the overlap between monetary and multidimensional child poverty in ethiopia*. *July*. http://www.csa.gov.et

Das, U. (2021). *Is Childhood Mortality Higher in Urban Poor Than in Rural India ?* 1–12. https://doi.org/10.21203/rs.3.rs-965163/v1

de Gruchy, T. (2020). Responding to the health needs of migrant farm workers in South Africa: Opportunities and challenges for sustainable community-based responses. *Health and Social Care in the Community*, *28*(1), 60–68. https://doi.org/10.1111/hsc.12840

Debela, S. A., Sisay, D., Negassa, M., Daba, C., Mesfin Tefera, Y., Debela, E. A., Goyomsa, G. G., Luke, A. O., Benayew Shiferaw, M., Asmare, M., & Gebrehiwot, M. (2023). Determinants of undernutrition among children aged 6–59 months during the COVID-19 pandemic: A hospital-based cross-sectional study in Ethiopia. *Journal of Public Health Research*, *12*(2). https://doi.org/10.1177/22799036231181174

Dendup, T., Zhao, Y., & Putra, I. G. N. E. (2020). Rural-urban differentials in the determinants of under-five mortality in Bhutan. *Journal of Health Research*, *35*(3), 226–239. https://doi.org/10.1108/JHR-09-2019-0208

Department of Economic and Social Affairs, P. D. (2022). World Population Prospects 2022. In *United Nation* (Issue 9). www.un.org/development/ desa/pd/.

Development Initiatives. (2021). 2021 Global Nutrition Report: The state of global nutrition. Bristol, UK: Development Initiatives. In *Global Nutrition Report*. https://globalnutritionreport.org/reports/2021-global-nutrition-report/

Devereux, S., Taye, H., C, I. I. P. L., & Ababa, A. (2006). Ethiopia's Productive Safety Net Programme (PSNP) Trends in PSNP Transfers Within Targeted Households Final Report. *Institute of Development Studies (IDS)*, *August*.

Dheresa, M., Roba, H. S., Daraje, G., Abebe, M., Tura, A. K., Yadeta, T. A., Dessie, Y., & Dingeta, T. (2022). Uncertainties in the path to 2030: Increasing trends of under-five mortality in the aftermath of Millennium Development Goal in Eastern Ethiopia. *Journal of Global Health*, *12*. https://doi.org/10.7189/JOGH.12.04010

EBI. (2014). *Government of the Federal Democratic Republic of Ethiopia: Ethiopia's Fifth National Report to the Convention on Biological Diversity Ethiopian Biodiversity*. *May*, 72.

Ekholuenetale, M., Okonji, O. C., Nzoputam, C. I., & Barrow, A. (2022). Inequalities in the prevalence of stunting, anemia and exclusive breastfeeding among African children. *BMC Pediatrics*, *22*(1), 1–14. https://doi.org/10.1186/s12887-022-03395-y

Ekholuenetale, M., Tudeme, G., Onikan, A., & Ekholuenetale, C. E. (2020). Socioeconomic inequalities in hidden hunger, undernutrition, and overweight among under-five children in 35 sub-Saharan Africa countries. *Journal of the Egyptian Public Health Association*, *95*(1). https://doi.org/10.1186/s42506-019-0034-5

Ekholuenetale, M., Wegbom, A. I., Tudeme, G., & Onikan, A. (2020). Household factors associated with infant and under-five mortality in sub-Saharan Africa countries. *International Journal of Child Care and Education Policy*, *14*(1), 1–15. https://doi.org/10.1186/s40723-020-00075-1

Endalew, B., Muche, M., & Tadesse, S. (2015). Assessment of food security situation in ethiopia: A Review. In *Asian Journal of Agricultural Research* (Vol. 9, Issue 2, pp. 55–68). https://doi.org/10.3923/ajar.2015.55.68

Endris, B. S., Dinant, G. J., Gebreyesus, S. H., & Spigt, M. (2021). Geospatial inequality of anaemia among children in Ethiopia. *Geospatial Health*, *16*(2). https://doi.org/10.4081/gh.2021.1036

Eozenou, P. H. V., Neelsen, S., & Lindelow, M. (2021). Child Health Outcome Inequalities in Low and Middle Income Countries. *Health Systems and Reform*, *7*(2). https://doi.org/10.1080/23288604.2021.1934955

Ethiopian Public Health Institute (EPHI) [Ethiopia] and ICF. (2021). *Ethiopia Mini Demographic and Health Survey 2019: Final Report. Rockville, Maryland, USA: EPHI and ICF*.

Ezeh, O. K., Agho, K. E., Dibley, M. J., Hall, J. J., & Page, A. N. (2015). Risk factors for postneonatal, infant, child and under-5 mortality in Nigeria: A pooled cross-sectional analysis. *BMJ Open*, *5*(3), 1–9. https://doi.org/10.1136/bmjopen-2014-006779

Fairlie, R. W. (2005). An extension of the Blinder-Oaxaca decomposition technique to logit and probit models. *Journal of Economic and Social Measurement*, *30*(4), 305–316. https://doi.org/10.3233/jem-2005-0259

FAO, IFAD, UNICEF, WFP. and WHO. (2021). The State of Food Security and Nutrition in the World 2021. Transforming food systems for food security, improved nutrition and affordable healthy diets for all. Rome, FAO. In *In Brief to The State of Food Security and Nutrition in the World 2021*. https://doi.org/10.4060/cb5409en

FAO; IFAD; UNICEF; WFP; and WHO; (2022). *The State of Food Security and Nutrition in the World 2022. Repurposing food and agriculture policies to make healthy diets more affordable. Rome, FAO.* https://doi.org/10.4060/cc0639en

FAO. (2016). AQUASTAT Country Profile – Ethiopia. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy. *FAO, AQUSAT Reports*, 11–12.

Federal Democratic Repulic of Ethiopia (FDRE). (2008). Federal *Republic of Ethiopia,* Ministry of

Health: *National Nutrition Program Strategy 2008-2015*. *January*. https://extranet.who.int/nutrition/gina/sites/default/filesstore/ETH%202008%20National%20Nutrition%20Strategy_1.pdf

Federal Democratic Repulic of Ethiopia (FDRE). (2016). *Government of Ethiopia National Nutrition Program, Strategy 2016-2020*. *July 2016*, 1–83. https://www.nipn.ephi.gov.et/sites/default/files/2020-05/NNP2_pdf.pdf

Federal Democratic Repulic of Ethiopia (FDRE). (2018). *Food and Nutrition policy Ethiopia*. *November*, 2008. https://www.nipn.ephi.gov.et/sites/default/files/2020-05/Food%20and%20Nutrition%20Policy.pdf

Federal Democratic Repulic of Ethiopia (FDRE). (2020). *Federal Democratic Republic of Ethiopia: the 2019 Article IV Consultation and Requests for Three-Year Arrangements Under the Extended Credit Facility and the Extended Fund Facility, IMF Country Report*. *20*, 4–44.

Federal Democratic Repulic of Ethiopia (FDRE). (2021). Ethiopia 2030: The Pathway to Prosperity Ten Years Perspective Development Plan (2021 – 2030) *https://www.lawethiopia.com/images/Policy_documents/10_year_plan_english_final.pdf*.

Fenta, H. M., Tesfaw, L. M., & Derebe, M. A. (2020). Trends and Determinants of Underweight among Under-Five Children in Ethiopia: Data from EDHS. *International Journal of Pediatrics (United Kingdom)*, *2020*. https://doi.org/10.1155/2020/3291654

Fenta, H. M., Zewotir, T., & Muluneh, E. K. (2021a). Disparities in childhood composite index of anthropometric failure prevalence and determinants across Ethiopian administrative zones. *PLoS ONE*, *16*(9 September), 1–17. https://doi.org/10.1371/journal.pone.0256726

Fenta, H. M., Zewotir, T., & Muluneh, E. K. (2021b). Spatial data analysis of malnutrition among children under-five years in Ethiopia. *BMC Medical Research Methodology*, *21*(1), 1–13. https://doi.org/10.1186/s12874-021-01391-x

Fenta, S. M., & Fenta, H. M. (2020). Risk factors of child mortality in Ethiopia: Application of multilevel two-part model. *PLoS ONE*, *15*(8 August). https://doi.org/10.1371/journal.pone.0237640

FMOH-FDRE. (2016). *National Strategy for Child Survival in Ethiopia 2015/16-2019/20 Maternal*. 7–66.

Forde, I., & Tripathi, V. (2018). Association of place of residence and under-five mortality in middle-and low-income countries: A meta-analysis. *Children*, *5*(4). https://doi.org/10.3390/children5040051

Gebreegziabher, T., Regassa, N., Wakefield, M., Pritchett, K., & Hawk, S. (2020). Disparities in the prevalence and risk factors of anaemia among children aged 6 24 months and 25 59 months in Ethiopia. *Journal of Nutritional Science*, *9*. https://doi.org/10.1017/jns.2020.29

Gebresilassie, Y. H., Nyatanga, P., & Gebreselassie, M. A. (2021). Determinants of Rural–Urban Differentials in Under-Five Child Mortality in Ethiopia. *European Journal of Development Research*, *33*(3), 710–734. https://doi.org/10.1057/s41287-020-00292-x

Geda, N. R., Feng, C. X., Henry, C. J., Lepnurm, R., Janzen, B., & Whiting, S. J. (2021). Multiple anthropometric and nutritional deficiencies in young children in Ethiopia: a multi-level analysis based on a nationally representative data. *BMC Pediatrics*, *21*(1), 1–12. https://doi.org/10.1186/s12887-020-02467-1

Gelman, A., & Hill, J. (2010). Multilevel logistic regression. *Data Analysis Using Regression and Multilevel/Hierarchical Models*, 301–324. https://doi.org/10.1017/cbo9780511790942.018

Gesese, A. A., & Khot, L. D. (2023). *Determinants of acute malnutrition among 6 – 59 months old children in public hospitals in Gambella town , Southwest Ethiopia : unmatched case-control study*. *September*, 1–13. https://doi.org/10.3389/fnut.2023.1212504

Getis, A., & Ord, J. K. (1992). The Analysis of Spatial Association by Use of Distance Statistics. *Geographical Analysis*, *24*(3), 189–206. https://doi.org/10.1111/j.1538-4632.1992.tb00261.x

Grebmer, K, Bernstein, J., Mukerji, R., Patterson, F., Wiemers, M., Ní Chéilleachair, R., Foley, C., Gitter, S., Ekstrom, K., & Fritschel, H. (2019). *2019 Global Hunger Index: The Challenge of Hunger and Climate Change*.

Grebmer, Klaus von, Bernst, J., Wiemers, M., Schiffer, T., Hanano, A., Towey, O., Chéilleachair, Ní, R., Foley, C., Gitter, S., Ekstrom, K., & Fritschel, H. (2021). *Global hunger index*. *October*, 1–54.

Greenland, S., & Drescher, K. (1993). *Maximum likelihood of the Attributable Fraction from Logistic Models*. http://www.uvm.edu/~rsingle/stat380/F04/possible/Greenland%2BDrescher_Biometrics-93_AttribFract.pdf

Hailu, B., Ji-Guo, W., & Hailu, T. (2021). Water, Sanitation, and Hygiene Risk Factors on the Prevalence of Diarrhea among Under-Five Children in the Rural Community of Dangila District, Northwest Ethiopia. *Journal of Tropical Medicine*, *2021*. https://doi.org/10.1155/2021/2688500

Hasan, Md Mehedi, Magalhaes, R. J. S., Ahmed, S., Pervin, S., Tariqujjaman, M., Fatima, Y., & Mamun, A. A. (2021). Geographical variation and temporal trend in anemia among children aged 6-59 months in low- And middle-income countries during 2000-2018: forecasting the 2030 SDG target. *Public Health Nutrition*, *24*(18), 6236–6246. https://doi.org/10.1017/S1368980021002482

Hasan, Mohammad Monirul, Uddin, J., Pulok, M. H., Zaman, N., & Hajizadeh, M. (2020). Socioeconomic inequalities in child malnutrition in bangladesh: Do they differ by region? *International Journal of Environmental Research and Public Health*, *17*(3). https://doi.org/10.3390/ijerph17031079

Heinrichs, H., Endris, B. S., Dejene, T., Dinant, G. J., & Spigt, M. (2021). Anaemia and its determinants among young children aged 6–23 months in Ethiopia (2005–2016). *Maternal and Child Nutrition*, *17*(2), 1–13. https://doi.org/10.1111/mcn.13082

Heinze, G., & Dunkler, D. (2017). Five myths about variable selection. *Transplant International*, *30*(1), 6–10. https://doi.org/10.1111/tri.12895

Hodge, A., Firth, S., Marthias, T., & Jimenez-Soto, E. (2014). Location matters: Trends in inequalities in child mortality in Indonesia. Evidence from repeated cross-sectional surveys. *PLoS ONE*, *9*(7). https://doi.org/10.1371/journal.pone.0103597

Hosmer, D. W., Hosmer, T., Le Cessie, S., & Lemeshow, S. (1997). A comparison of goodness-of-fit tests for the logistic regression model. *Statistics in Medicine*, *16*(9), 965–980. https://doi.org/10.1002/(SICI)1097-0258(19970515)16:9<965::AID-SIM509>3.0.CO;2-O

Hosseinpoor, A. R., Bergen, N., Barros, A. J. D., Wong, K. L. M., Boerma, T., & Victora, C. G. (2016). Monitoring subnational regional inequalities in health: Measurement approaches and challenges. *International Journal for Equity in Health*, *15*(1). https://doi.org/10.1186/s12939-016-0307-y

Houweling, T. A. J., & Kunst, A. E. (2010). Socio-economic inequalities in childhood mortality in low- and middle-income countries: A review of the international evidence. *British Medical Bulletin*, *93*(1), 7–26. https://doi.org/10.1093/bmb/ldp048

IISD/IFPRI. (2022). *Country Diagnostic Report; Ethiopa-Ceres2030 Deep Dives into the Nexus of Food*

Systems, Climate Change, and Diet. https://www.iisd.org/system/files/2022-05/country-diagnostic-ethiopia-food-systems-climate-change-diets.pdf

Jann, B. (2008). A Stata implementation of the Blinder-Oaxaca decomposition. *The Stata Journal*, *8*(4), 453–479. www.socio.ethz.ch

Jayathilaka, R., Adikari, H., Liyanage, R., Udalagama, R., & Wanigarathna, N. (2021). Cherish your children: socio-economic and demographic characteristics associated with child mortality. *BMC Public Health*, *21*(1), 1–14. https://doi.org/10.1186/s12889-021-11276-9

Jember, T. A., Teshome, D. F., Gezie, L. D., & Agegnehu, C. D. (2021). Spatial variation and determinants of childhood anemia among children aged 6 to 59 months in Ethiopia: further analysis of Ethiopian demographic and health survey 2016. *BMC Pediatrics*, *21*(1), 1–14. https://doi.org/10.1186/s12887-021-02901-y

Johnston, R., Jones, K., & Manley, D. (2018). Confounding and collinearity in regression analysis: a cautionary tale and an alternative procedure, illustrated by studies of British voting behaviour. *Quality and Quantity*, *52*(4), 1957–1976. https://doi.org/10.1007/s11135-017-0584-6

Kalu, R. E., & Etim, K. D. (2018). Factors associated with malnutrition among underfive children in developing countries: A review. *Global Journal of Pure and Applied Sciences*, *24*(1), 69. https://doi.org/10.4314/gjpas.v24i1.8

Karlsson, O., Kim, R., Sarwal, R., James, K. S., & Subramanian, S. V. (2021). Trends in underweight, stunting, and wasting prevalence and inequality among children under three in Indian states, 1993–2016. *Scientific Reports*, *11*(1), 1–11. https://doi.org/10.1038/s41598-021-93493-1

Kasaye, H. K., Bobo, F. T., Yilma, M. T., & Woldie, M. (2019). Poor nutrition for under-five children from poor households in Ethiopia: Evidence from 2016 Demographic and Health Survey. *PLoS ONE*, *14*(12), 1–16. https://doi.org/10.1371/journal.pone.0225996

Kejo, D., Petrucka, P., Martin, H., Kimanya, M., & Mosha, T. (2018). Prevalence and predictors of anemia among children under 5 years of age in Arusha District, Tanzania. *Pediatric Health, Medicine and Therapeutics*, *Volume 9*, 9–15. https://doi.org/10.2147/phmt.s148515

Kennedy, E., Mersha, G. A., Biadgilign, S., Tessema, M., Zerfu, D., Gizaw, R., & Kershaw, M. (2020). Nutrition Policy and Governance in Ethiopia: What Difference Does 5 Years Make? *Food and Nutrition Bulletin*, *41*(4), 494–502. https://doi.org/10.1177/0379572120957218

Khulu, C., Ramroop, S., & Habyarimana, F. (2022). Modelling Factors Associated with Malnutrition and Anemia in Children under Five Years in Angola, Senegal, and Malawi by using a Joint Model. *The Open Public Health Journal*, *16*(1), 1–8. https://doi.org/10.2174/18749445-v15-e221220-2022-82

Kiross, G. T., Chojenta, C., Barker, D., Tiruye, T. Y., & Loxton, D. (2019). The effect of maternal education on infant mortality in Ethiopia: A systematic review and meta-analysis. *PLoS ONE*, *14*(7), 1–12. https://doi.org/10.1371/journal.pone.0220076

Kondo, K. (2016). Hot and cold spot analysis using Stata. *Stata Journal*, *16*(3), 613–631. https://doi.org/10.1177/1536867x1601600304

Kondo, K. (2021). Testing for Global Spatial Autocorrelation in Stata: Moransi version 1.21. *Statistical Software Components S458473, Boston College Department of Economics.*, *2021*(2016), 1–10. https://pro.arcgis.com/en/pro-app/tool-reference/spatial-statistics/

Krishna, A., Mejía-Guevara, I., McGovern, M., Aguayo, V. M., & Subramanian, S. V. (2018a). Trends in inequalities in child stunting in South Asia. *Maternal and Child Nutrition*, *14*.

https://doi.org/10.1111/mcn.12517

Krishna, A., Mejía-Guevara, I., McGovern, M., Aguayo, V. M., & Subramanian, S. V. (2018b). Trends in inequalities in child stunting in South Asia. *Maternal and Child Nutrition*, *14*(August 2017), 1–12. https://doi.org/10.1111/mcn.12517

Lee, S. E., & Dahinten, V. S. (2021). Using dominance analysis to identify the most important dimensions of safety culture for predicting patient safety. *International Journal of Environmental Research and Public Health*, *18*(15). https://doi.org/10.3390/ijerph18157746

Lemessa, R., Aga, G., Tafese, A., & Senbeto, T. (2022). Malnutrition in Ethiopia: pattern analysis and associated factors among under-five children. *Nutrition and Food Science*. https://doi.org/10.1108/NFS-12-2021-0393

Levin, K. A. (2006). Study design VI – ecological studies. *Evidence-Based Dentistry*, *7*(4), 108. https://doi.org/10.1038/sj.ebd.6400454

Li, J. (2017). Rate decomposition for aggregate data using Das Gupta's method. *Stata Journal*, *17*(2), 490–502. https://doi.org/10.1177/1536867x1701700213

Liyew, A. M., Kassie, A., Teshale, A. B., Alem, A. Z., Yeshaw, Y., & Tesema, G. A. (2021). Exploring spatiotemporal distribution of under-five mortality in Ethiopia: Further analysis of Ethiopian Demographic and Health Surveys 2000, 2005, 2011 and 2016. *BMJ Paediatrics Open*, *5*(1), 1–9. https://doi.org/10.1136/bmjpo-2021-001047

Luke, D. (2020). *Multilevel modeling: The null model. Second edition.* SAGE Publications, Inc.,. https://doi.org/https://doi.org/10.4135/9781544310305

Macharia, P. M., Giorgi, E., Thuranira, P. N., Joseph, N. K., Sartorius, B., Snow, R. W., & Okiro, E. A. (2019). Sub national variation and inequalities in under-five mortality in Kenya since 1965. *BMC Public Health*, *19*(1), 1–12. https://doi.org/10.1186/s12889-019-6474-1

Maleta, K. (2006). *Undernutrition*. Malawi Medical Journal.*18*(December), 189–205. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3345626/

Mastercard. (2019). *Ethiopia ' s Productive Safety Net Programme : Addressing Food Insecurity with Food and Cash Transfers*. *21 FEBRUARY*, 1–27.

Mberu, B., Herbst, C. H., Black, R. E., Eisele, T., & Lawn, J. E. (2023). Trends and inequalities in under-five mortality in sub-Saharan Africa, 1990-2020: a burden of disease analysis. The Lancet Global Health, 11(1), e13-e28. doi: 10.1016/S2214-109X(22)00421-9

Mckinnon, B., Harper, S., Kaufman, J. S., & Bergevin, Y. (2014). Socioeconomic inequality in neonatal mortality in countries of low and middle income : a multicountry analysis. *The Lancet Global Health*, *2*(3), e165–e173. https://doi.org/10.1016/S2214-109X(14)70008-7

Mebrahtom, S., Worku, A., & Gage, D. J. (2022). The risk of water, sanitation and hygiene on diarrhea-related infant mortality in eastern Ethiopia: a population-based nested case-control. *BMC Public Health*, *22*(1), 1–14. https://doi.org/10.1186/s12889-022-12735-7

Mejía-Guevara, I., Corsi, D. J., Perkins, J. M., Kim, R., & Subramanian, S. V. (2018). Variation in anthropometric status and growth failure in lowand middle-income countries. *Pediatrics*, *141*(3). https://doi.org/10.1542/peds.2017-2183

Melli, L. C. F. L., & Waldman, E. A. (2009). Temporal trends and inequality in under-5 mortality from diarrhea. *Jornal de Pediatria*, *85*(1), 21–27. https://doi.org/10.2223/JPED.1856

MOA. (2015). *Federal Democratic Republic of Ethiopia Ministry of Agriculture Agricultural Growth Program II (AGP-II) Program Design Document January 2015 Addis Ababa | Page*. *January*.

MOH. (2020). *Realizing Universal Health Coverage Through Primary Health Care. A roadmap for optimizing the Ethiopian Health Extension Program 2020-2035. July 2020, Addis Ababab Ehtiopia*.

MOH. (2021). *Health Sector Transformation Plan II*. https://ictet.org/docs/index.php/digital-ethiopia/hstp-ii/detail

Mohajan, H. K. (2013). *Ethiopia : A socio*-economic study. *Juornal of Business Management and Administration 3(Agugust) 2023. https://core.ac.uk/download/pdf/213953239.pdf*

Mohamed, A. A. (2017). Food Security Situation in Ethiopia: A Review Study. *International Journal of Health Economics and Policy*, *2*(311), 86–96. https://doi.org/10.11648/j.hep.20170203.11

Mohammed, S. H., Muhammad, F., Pakzad, R., & Alizadeh, S. (2019). Socioeconomic inequality in stunting among under-5 children in Ethiopia: A decomposition analysis. *BMC Research Notes*, *12*(1), 1–5. https://doi.org/10.1186/s13104-019-4229-9

Moradhvaj, & Samir, K. C. (2023). Differential impact of maternal education on under-five mortality in rural and urban India. *Health and Place*, *80*(September 2022), 102987. https://doi.org/10.1016/j.healthplace.2023.102987

Moran, P. A. P. (1948). The Interpretation of Statistical Maps. *Journal of the Royal Statistical Society: Series B (Methodological)*, *10*(2), 243–251. https://doi.org/10.1111/j.2517-6161.1948.tb00012.x

Mosley, W. Henry, Chen, L. C. (1984). An Analytical Framework for the Study of Child Survival in Developing Countries Population and Development Review , Vol. 10, Supplement: Child Survival: Strategies for Research. (1984), pp. 25-45. *Population and Development Review, Supplement:Child Survival: Strategies for Research*, *10*(1984), 25–45.

Mosley, W. H., & Chen, L. C. (2003). An analytical framework for the study of child survival in developing countries. Extracted from: Population and Development Review 1984;10 Suppl:25–45. *Child Survival: Strategies for Research*, *February 2003*, 25–45. https://doi.org/10.2307/2807954

Mugo, N. S., Agho, K. E., Zwi, A. B., Damundu, E. Y., & Dibley, M. J. (2018). Determinants of neonatal, infant and under-five mortality in a war-affected country: Analysis of the 2010 Household Health Survey in South Sudan. *BMJ Global Health*, *3*(1), 1–15. https://doi.org/10.1136/bmjgh-2017-000510

Mukherjee, A., Rizu, & Parashar, R. (2022). Longitudinal trends in the health outcomes among children of the North Eastern States of India: a comparative analysis using national DHS data from 2006 to 2020. *European Journal of Clinical Nutrition*, *76*(11), 1528–1535. https://doi.org/10.1038/s41430-022-01147-w

Mulholland, E. K., Smith, L., Carneiro, I., Becherc, H., & Lehmann, D. (2008). Equity and child-survival strategies. *Bulletin of the World Health Organization*, *86*(5), 399–407. https://doi.org/10.2471/BLT.07.044545

Mwene-Batu, P., Bisimwa, G., Baguma, M., Chabwine, J., Bapolisi, A., Chimanuka, C., Molima, C., Dramaix, M., Kashama, N., Macq, J., & Donnen, P. (2020). Long-term effects of severe acute malnutrition during childhood on adult cognitive, academic and behavioural development in African fragile countries: The Lwiro cohort study in Democratic Republic of the Congo. *PLoS ONE*, *15*(12 December 2020), 1–15. https://doi.org/10.1371/journal.pone.0244486

Nahalomo, A., Iversen, P. O., Andreassen, B. A., Kaaya, A. N., Rukooko, A. B., Tushabe, G., Nateme, N.

C., & Rukundo, P. M. (2022). Malnutrition and Associated Risk Factors among Children 6-59 Months Old in the Landslide-Prone Bududa District, Eastern Uganda: A Cohort Study. *Current Developments in Nutrition*, *6*(2). https://doi.org/10.1093/cdn/nzac005

Nandy, S., Irving, M., Gordon, D., Subramanian, S. V., & Davey Smith, G. (2005). Poverty, child undernutrition and morbidity: New evidence from india. *Bulletin of the World Health Organization*, *011650*(04), 210–216. https://doi.org/10.4324/9781315260495-39

Nankinga, Olivia; Danstan Aguta; and Catherine, K. (2019). *Trends and Determinants of Anemia in Uganda: Further Analysis of the Demographic and Health Surveys. DHS Working Paper No. 149. Rockville, Maryland, USA: ICF.* https://doi.org/10.2147/phmt.s258114

National Plan Commission. (2017). *Voluntary National Reviews on SDGs of Ethiopia: Government Commitments, National Ownership and Performance Trends*. *June*, 1–52.

National Planning Commission. (2015). *Assessment of Ethiopia's Progress to MDGs*. https://planipolis.iiep.unesco.org/sites/default/files/ressources/ethiopia_mdg_2014.pd

Negussie, S. T., & Nigatu, R. G. (2023a). Levels and trends in key socioeconomic inequalities in childhood undernutrition in Ethiopia: evidence from Ethiopia demographic and health surveys 2000-2019. *Discover Social Science and Health*, *3*(1). https://doi.org/10.1007/s44155-023-00034-4

Negussie, S. T., & Nigatu, R. G. (2023b). Trends in regional inequalities in childhood anemia in Ethiopia: evidence from the 2005–2016 Ethiopian Demographic and Health Surveys. *Discover Social Science and Health*, *3*(1). https://doi.org/10.1007/s44155-023-00038-0

Neupane, B., Rijal, S., G.c., S., & Basnet, T. B. (2020). Andersen's model on determining the factors associated with antenatal care services in Nepal: An evidence-based analysis of Nepal demographic and health survey 2016. *BMC Pregnancy and Childbirth*, *20*(1), 1–11. https://doi.org/10.1186/s12884-020-02976-y

Newson, R. B. (2013). Attributable and unattributable risks and fractions and other scenario comparisons. *Stata Journal*, *13*(4), 672–698. https://doi.org/10.1177/1536867x1301300402

Nguyen, P. H., Scott, S., Avula, R., Tran, L. M., & Menon, P. (2018). Trends and drivers of change in the prevalence of anaemia among 1 million women and children in India, 2006 to 2016. *BMJ Global Health*, *3*(5), 1–12. https://doi.org/10.1136/bmjgh-2018-001010

Nkosi-Gondwe, T., Calis, J., van Hensbroek, M. B., Bates, I., Blomberg, B., & Phiri, K. S. (2021). A cohort analysis of survival and outcomes in severely anaemic children with moderate to severe acute malnutrition in Malawi. *PLoS ONE*, *16*(2 February), 1–11. https://doi.org/10.1371/journal.pone.0246267

Noor, F. M., & Udddin, M. A. (2021). *Determinants of Under-five Child Mortality : Evidence from Bangladesh Multiple Indicator Cluster Survey*. 1–15.

NUPI and SIPRI. (2022). *Fact Sheet Ethiopia*. *June*. https://sipri.org/sites/default/files/NUPI Fact Sheet Ethiopia June 2022 LR5%5B12%5D.pdf

O'Donnell, O., van Doorslaer, E., Wagstaff, A., & Lindelow, M. (2007). Analyzing Health Equity Using Household Survey Data. In *Analyzing Health Equity Using Household Survey Data*. https://doi.org/10.1596/978-0-8213-6933-3

Obasohan, P. E., Walters, S. J., Jacques, R., & Khatab, K. (2022). Individual, household and area predictors of anaemia among children aged 6–59 months in Nigeria. *Public Health in Practice*, *3*(December 2021), 100229. https://doi.org/10.1016/j.puhip.2022.100229

OCHA. (2022). *Ethiopia: Drought - 2015-2023*. *April*, 2022. https://reliefweb.int/disaster/dr-2015-000109-eth

Okoli, C. I., Hajizadeh, M., Rahman, M. M., & Khanam, R. (2022). Geographic and socioeconomic inequalities in the survival of children under-five in Nigeria. *Scientific Reports*, *12*(1), 1–12. https://doi.org/10.1038/s41598-022-12621-7

Pearce, A., Dundas, R., Whitehead, M., & Taylor-Robinson, D. (2019). Pathways to inequalities in child health. *Archives of Disease in Childhood*, *104*(10), 998–1003. https://doi.org/10.1136/archdischild-2018-314808

Pongou, R. (2013). Why Is Infant Mortality Higher in Boys Than in Girls? A New Hypothesis Based on Preconception Environment and Evidence From a Large Sample of Twins. *Demography, 50*(2), 421–444. https://doi.org/10.1007/s13524-012-0161-5

Powers, D. A., Yoshioka, H., & Yun, M. S. (2011). Mvdcmp: Multivariate Decomposition for Nonlinear Response Models. *Stata Journal*, *11*(4), 556–576. https://doi.org/10.1177/1536867X1201100404

Pulok, M. H., van Gool, K., Hajizadeh, M., Allin, S., & Hall, J. (2020). Measuring horizontal inequity in healthcare utilisation: a review of methodological developments and debates. *European Journal of Health Economics*, *21*(2), 171–180. https://doi.org/10.1007/s10198-019-01118-2

Rabbani, A., Khan, A., Yusuf, S., & Adams, A. (2016). Trends and determinants of inequities in childhood stunting in Bangladesh from 1996/7 to 2014. *International Journal for Equity in Health*, *15*(1), 1–14. https://doi.org/10.1186/s12939-016-0477-7

Rahman, M. M., & Alam, K. (2021). The Role of Socio-economic and Female Indicators on Child Mortality Rate in Bangladesh: A Time Series Analysis. *Omega (United States), 0(0),* 1–24. https://doi.org/10.1177/0030222821993616

Rebouças, P., Falcão, I. R., & Barreto, M. L. (2022). Social inequalities and their impact on children's health: a current and global perspective. *Jornal de Pediatria, 98,* S55–S65. https://doi.org/10.1016/j.jped.2021.11.004

Ribeiro-Silva, R. de C., Silva, N. de J., Felisbino-Mendes, M. S., Falcão, I. R., de Andrade, R. da C. S., Silva, S. A., Nilson, E. A. F., Spaniol, A. M., Fiaccone, R. L., Paixão, E., Ichihara, M. Y. T., Velasquez-Melendez, G., & Barreto, M. L. (2021). Time trends and social inequalities in child malnutrition: nationwide estimates from Brazil's Food and Nutrition Surveillance System, 2009-2017. *Public Health Nutrition*, 1–31. https://doi.org/10.1017/s1368980021004882

Rizal, M. F., & van Doorslaer, E. (2019). Explaining the fall of socioeconomic inequality in childhood stunting in Indonesia. *SSM - Population Health*, *9*, 100469. https://doi.org/10.1016/j.ssmph.2019.100469

Romaric BADO, A., & Susuman APPUNNI, S. (2015). Decomposing Wealth-Based Inequalities in Under-Five Mortality in West Africa. In *Iran J Public Health* (Vol. 44, Issue 7). http://ijph.tums.ac.ir

Rono, J., Kamau, L., Mwangwana, J., Waruguru, J., Aluoch, P., & Njoroge, M. (2022). A policy analysis of policies and strategic plans on Maternal, Newborn and Child Health in Ethiopia. *International Journal for Equity in Health*, *21*(1), 1–9. https://doi.org/10.1186/s12939-022-01656-x

Rückinger, S., Von Kries, R., & Toschke, A. M. (2009). An illustration of and programs estimating attributable fractions in large scale surveys considering multiple risk factors. *BMC Medical Research Methodology*, *9*(1), 1–6. https://doi.org/10.1186/1471-2288-9-7

Ruducha, J., Mann, C., Singh, N. S., Gemebo, T. D., Tessema, N. S., Baschieri, A., Friberg, I., Zerfu, T. A., Yassin, M., Franca, G. A., & Berman, P. (2017). How Ethiopia achieved Millennium Development Goal 4 through multisectoral interventions: a Countdown to 2015 case study. *The Lancet Global Health*, *5*(11). https://doi.org/10.1016/S2214-109X(17)30331-5

Sachs, J.D., Lafortune, G., Fuller, G., Drumm, E. (2023). *Implementing the SDG Stimulus. Sustainable Development Report 2023*. SDSN, Dublin: Dublin University Press, 2023. 10.25546/102924. https://s3.amazonaws.com/sustainabledevelopment.report/2023/sustainable-development-report-2023.pdf

Safiri, S., Kolahi, A. A., Noori, M., Nejadghaderi, S. A., Karamzad, N., Bragazzi, N. L., Sullman, M. J. M., Abdollahi, M., Collins, G. S., Kaufman, J. S., & Grieger, J. A. (2021). Burden of anemia and its underlying causes in 204 countries and territories, 1990–2019: results from the Global Burden of Disease Study 2019. *Journal of Hematology and Oncology*, *14*(1), 1–16. https://doi.org/10.1186/s13045-021-01202-2

Sahiledengle, B., Mwanri, L., Petrucka, P., Kumie, A., Beressa, G., Atlaw, D., Tekalegn, Y., Zenbaba, D., Desta, F., Teferu, Z., Wordofa, D., Seyoum, K., Gomora, D., Negash, G., & Agho, K. E. (2022). Determinants of undernutrition among young children in Ethiopia. *Scientific Reports*, *12*(1), 1–18. https://doi.org/10.1038/s41598-022-25160-y

Sarkodie, A. O. (2021). Factors influencing under-five mortality in rural- urban Ghana: An applied survival analysis. *Social Science and Medicine*, *284*(July), 114185. https://doi.org/10.1016/j.socscimed.2021.114185

Sastry, N. (2020). *Trends in Socioeconomic Inequalities in Mortality in Developing Countries : The Case of Child Survival in São Paulo , Brazil Author (s): Narayan Sastry Published by : Springer on behalf of the Population Association of America Stable URL : https://www.j*. *41*(3), 443–464.

Sato, R., Bolongaita, S., Memirie, S. T., Harttgen, K., De Neve, J. W., & Verguet, S. (2023). Joint distribution of child mortality and wealth across 30 sub-Saharan African countries over 2000-2019. *Journal of Global Health*, *13*, 04009. https://doi.org/10.7189/jogh.13.04009

Schultz, T. P. (1984). Studying the impact of household economic and community variables on child mortality. *Child Survival: Strategies for Research*, *10*(1984), 215–235. https://doi.org/10.2307/2807962

Seboka, B. T., Hailegebreal, S., Yehualashet, D. E., & Demeke, A. D. (2021). Tracking progress in anthropometric failure among under-five children in Ethiopia: a geospatial and multilevel analysis. *Archives of Public Health*, *79*(1), 1–17. https://doi.org/10.1186/s13690-021-00615-2

Seifu, B. L., & Tesema, G. A. (2022). Individual-and community-level factors associated with anemia among children aged 6–23 months in sub-Saharan Africa: evidence from 32 sub-Saharan African countries. *Archives of Public Health*, *80*(1), 1–12. https://doi.org/10.1186/s13690-022-00950-y

Senaviratna, N. A. M. R., & A. Cooray, T. M. J. (2019). Diagnosing Multicollinearity of Logistic Regression Model. *Asian Journal of Probability and Statistics*, *5*(2), 1–9. https://doi.org/10.9734/ajpas/2019/v5i230132

Shaka, M. F., Woldie, Y. B., Lola, H. M., Olkamo, K. Y., & Anbasse, A. T. (2020). Determinants of undernutrition among children under-five years old in southern Ethiopia: Does pregnancy intention matter? A community-based unmatched case-control study. *BMC Pediatrics*, *20*(1), 1–10. https://doi.org/10.1186/s12887-020-2004-7

Sharaf, M. F., & Rashad, A. S. (2015). Regional inequalities in child malnutrition in Egypt, Jordan, and

Yemen: a Blinder-Oaxaca decomposition analysis. *Health Economics Review*, *6*(1). https://doi.org/10.1186/s13561-016-0097-3

Sharrow, D., Hug, L., You, D., Alkema, L., Black, R., Cousens, S., Croft, T., Gaigbe-Togbe, V., Gerland, P., Guillot, M., Hill, K., Masquelier, B., Mathers, C., Pedersen, J., Strong, K. L., Suzuki, E., Wakefield, J., & Walker, N. (2022). Global, regional, and national trends in under-5 mortality between 1990 and 2019 with scenario-based projections until 2030: a systematic analysis by the UN Inter-agency Group for Child Mortality Estimation. *The Lancet Global Health*, *10*(2), e195–e206. https://doi.org/10.1016/S2214-109X(21)00515-5

Shibre, G., Idriss-Wheeler, D., & Yaya, S. (2020). Inequalities and trends in Neonatal Mortality Rate (NMR) in Ethiopia: Evidence from the Ethiopia Demographic and Health Surveys, 2000–2016. PLoS ONE, 15(6), e0234483. doi: 10.1371/journal.pone.0234483

Shibre, G., Zegeye, B., Ahinkorah, B. O., Seidu, A.-A., Ameyaw, E. K., Keetile, M., & Yaya, S. (2021). Trends in socio-economic, sex and geographic disparities in childhood underweight in Mauritania: evidence from Multiple Indicator Cluster Surveys (2007–2015). *International Health*, *June*. https://doi.org/10.1093/inthealth/ihab040

Shukla, A. K., Srivastava, S., & Verma, G. (2019). Effect of maternal anemia on the status of iron stores in infants: A cohort study. *Journal of Family and Community Medicine*, *26*(2), 118–122. https://doi.org/10.4103/jfcm.JFCM_115_18

Sinning, M., Hahn, M., & Bauer, T. K. (2008). The Blinder-Oaxaca decomposition for nonlinear regression models. *Stata Journal*, *8*(4), 480–492. https://doi.org/10.1177/1536867x0800800402

Smith, L., Frankenberger, T., Langworthy, B., Martin, S., Spangler, T., & Nelson, S. (2015). Ethiopia Pastoralist Areas Resilience Improvement and Market Expansion (PRIME) Project Impact Evaluation Baseline Survey Report Volume 1 : Main Report. *USAID: Washington DC, USA*, *1*(January), 1–155. https://pdf.usaid.gov/pdf_docs/PA00MGHS.pdf

Snijders and Bosker. (2012). *Multilevel Analysis: An Introduction to Basic and Advanced Multilevel Modeling, second edition. Sage Publishers, 2012*. *ISBN 97818*(Sage Publishers). https://www.stats.ox.ac.uk/~snijders/MLB_new_S.pdf

Sreeramareddy, C. T., Harsha Kumar, H. N., & Sathian, B. (2013). Time trends and inequalities of under-five mortality in Nepal: A secondary data analysis of four demographic and health surveys between 1996 and 2011. *PLoS ONE*, *8*(11), 1–12. https://doi.org/10.1371/journal.pone.0079818

Ssentongo, P., Ssentongo, A. E., Ba, D. M., Ericson, J. E., Na, M., Gao, X., Fronterre, C., Chinchilli, V. M., & Schiff, S. J. (2021). Global, regional and national epidemiology and prevalence of child stunting, wasting and underweight in low- and middle-income countries, 2006–2018. *Scientific Reports*, *11*(1), 1–12. https://doi.org/10.1038/s41598-021-84302-w

StataCorp. (2021). *Multilevel Mixed Effects REFERENCE MANUAL RELEASE 17*. A Stata Press Publication StataCorp LLC College Station, Texas. https://www.stata.com/manuals/me.pdf

Stevens, G. A., Paciorek, C. J., Flores-Urrutia, M. C., Borghi, E., Namaste, S., Wirth, J. P., Suchdev, P. S., Ezzati, M., Rohner, F., Flaxman, S. R., & Rogers, L. M. (2022a). National, regional, and global estimates of anaemia by severity in women and children for 2000–19: a pooled analysis of population-representative data. *The Lancet Global Health*, *10*(5), e627–e639. https://doi.org/10.1016/s2214-109x(22)00084-5

Stevens, G. A., Paciorek, C. J., Flores-Urrutia, M. C., Borghi, E., Namaste, S., Wirth, J. P., Suchdev, P. S., Ezzati, M., Rohner, F., Flaxman, S. R., & Rogers, L. M. (2022b). National, regional, and global estimates of anaemia by severity in women and children for 2000–19: a pooled analysis of population-representative data. *The Lancet Global Health*, *10*(5), e627–e639. https://doi.org/10.1016/S2214-109X(22)00084-5

Subramanyam, M. A., Kawachi, I., Berkman, L. F., & Subramanian, S. V. (2010). Socioeconomic inequalities in childhood undernutrition in India: Analyzing trends between 1992 and 2005. *PLoS ONE*, *5*(6). https://doi.org/10.1371/journal.pone.0011392

Sun, J., Wu, H., Zhao, M., Magnussen, C. G., & Xi, B. (2021). Prevalence and changes of anemia among young children and women in 47 low- and middle-income countries, 2000-2018. *EClinicalMedicine*, *41*, 101136. https://doi.org/10.1016/j.eclinm.2021.101136

Sunguya, B. F., Zhu, S., Paulo, L. S., Ntoga, B., Abdallah, F., Assey, V., Mpembeni, R., & Huang, J. (2020a). Regional disparities in the decline of anemia and remaining challenges among children in tanzania: Analyses of the tanzania demographic and health survey 2004–2015. *International Journal of Environmental Research and Public Health*, *17*(10), 1–14. https://doi.org/10.3390/ijerph17103492

Sunguya, B. F., Zhu, S., Paulo, L. S., Ntoga, B., Abdallah, F., Assey, V., Mpembeni, R., & Huang, J. (2020b). Regional disparities in the decline of anemia and remaining challenges among children in tanzania: Analyses of the tanzania demographic and health survey 2004–2015. *International Journal of Environmental Research and Public Health*, *17*(10), 1–15. https://doi.org/10.3390/ijerph17103492

Tangcharoensathien, V., Sudhakar, M., Birhanu, Z., Abraham, G., Bawah, A., Kyei, P., Biney, A., Shroff, Z. C., Witthayapipopsakul, W., & Panichkriangkrai, W. (2022). Health Policy and Systems Research Capacities in Ethiopia and Ghana: Findings From a Self-Assessment. *Global Health, Science and Practice*, *10*, 1–12. https://doi.org/10.9745/GHSP-D-21-00715

Tariku, S., & Gara, L. (2016). Place of diversity in the current Ethiopian education and training policy: Analysis of Cardinal dimensions. *Educational Research and Reviews*, *11*(8), 582–588. https://doi.org/10.5897/err2015.2614

Tesema, G. A., Worku, M. G., Tessema, Z. T., Teshale, A. B., Alem, A. Z., Yeshaw, Y., Alamneh, T. S., & Liyew, A. M. (2021). Prevalence and determinants of severity levels of anemia among children aged 6-59 months in sub-Saharan Africa: A multilevel ordinal logistic regression analysis. *PLoS ONE*, *16*(4 April), 1–21. https://doi.org/10.1371/journal.pone.0249978

Tesema, G. A., Yeshaw, Y., Worku, M. G., Tessema, Z. T., & Teshale, A. B. (2021). Pooled prevalence and associated factors of chronic undernutrition among under-five children in East Africa: A multilevel analysis. *PLoS ONE*, *16*(3 March), 1–17. https://doi.org/10.1371/journal.pone.0248637

Tesema, M. T., & Braeken, J. (2018). Regional inequalities and gender differences in academic achievement as a function of educational opportunities: Evidence from Ethiopia. *International Journal of Educational Development*, *60*(November 2017), 51–59. https://doi.org/10.1016/j.ijedudev.2017.10.023

Tesfaye, T. S., Tessema, F., & Jarso, H. (2020). Prevalence of anemia and associated factors among "apparently healthy" urban and rural residents in Ethiopia: A comparative cross-sectional study. *Journal of Blood Medicine*, *11*, 89–96. https://doi.org/10.2147/JBM.S239988

Tessema , G.A.; Berheto, T.M.; Pereira, G.; Misganaw, A; Kinfu, F. (2023). National and subnational burden of under-5, infant, and neonatal mortality in Ethiopia, 1990–2019: Findings from the Global Burden of Disease Study 2019. *PLOS Global Public Health*, *3*(6), e0001471. https://doi.org/10.1371/journal.pgph.0001471

Tessema, Z. T., Tebeje, T. M., & Gebrehewet, L. G. (2022). Geographic variation and factors associated with under-five mortality in Ethiopia. A spatial and multilevel analysis of Ethiopian mini demographic and health survey 2019. *PLoS ONE*, *17*(10 October), 1–17. https://doi.org/10.1371/journal.pone.0275586

Tibebu, N. S., Emiru, T. D., Tiruneh, C. M., Nigat, A. B., Abate, M. wubneh, Getu, B. D., & Mekonnen, A. B. (2022). Potential determinant factors of under-five mortality in the Amhara region of Ethiopia. *BMC Pediatrics*, *22*(1), 1–7. https://doi.org/10.1186/s12887-022-03253-x

Tighe and Schatschneider. (2014). A Dominance Analysis Approach to Determining Predictor Importance in Third, Seventh, and Tenth Grade Reading Comprehension Skills. *Physiology & Behavior*, *176*(10), 139–148. https://doi.org/10.1007/s11145-013-9435-6.A

Tobler, W. R. (1970). A Computer Movie Simulating Urban Growth in the Detroit Region. *Economic Geography , Jun., 1970, Vol. 46, Supplement: Proceedings. International Geographical Union. Commission on Quantitative Methods (Jun., 1970), Pp. 234-240*, *46*, 234–240.

Touré, S., Weeks, J., Lopez-Carr, D., & Stow, D. (2020). Evaluating links between dynamic urban landscapes and underfive child mortality in Accra, Ghana. *Demographic Research*, *42*(20), 589–614. https://doi.org/10.4054/DEMRES.2020.42.20

Transitional Goverment of Ethiopia. (1993). *Health Policy of Ethiopia*. 1–11. https://faolex.fao.org/docs/pdf/eth174474.pdf

UN. (2022). SDG indicator metadata 01-04-01. *Https://Unstats.Un.Org/Sdgs/Metadata/Files/Metadata-03-02-01.Pdf*, *24*(January), 3–7. https://unstats.un.org/sdgs/metadata/files/Metadata-01-04-01.pdf

UN IGME. (2022). *Levels & trends in child mortality : Estimates developed by the United Nations Inter-agency Group for Child Mortality Estimation 2022*. https://www.childhealthtaskforce.org/resources/report/2023/united-nations-inter-agency-group-child-mortality-estimation-un-igme-report

UNDP. (2016). *From the MDGs to Sustainable Development for All: Lessons from 15 years' practice; United Nations Development Program (UNDP), 2016, New York.*

UNDP. (2020). Human Development Report 2020: The Next Frontier Human Development and the Anthropocene. *UNDP: New York, NY, USA*, 1–7.

UNDP. (2021). *Multidimensional Poverty Index 2021: Unmasking disparities by ethnicity, caste and gender. Briefing note for countries on the 2021 Multidimensional Poverty Index: Ethiopia*. 1–2.

UNDP. (2022). Ethiopia 2030: A Country transformed? Options for A Next Generation of Reforms. *Working Paper Series* |. https://www.undp.org/sites/g/files/zskgke326/files/2023-03/UNDP Ethiopia_Working paper series 2.pdf

UNICEF/WHO/WORLD BANK. (2021). Levels and trends in child malnutrition: Key Findings of the 2021 edition. *Who*. https://www.who.int/publications/i/item/9789240025257

UNICEF. (1998). The State of the World's Children. In *oxford University press*. https://www.unicef.org/media/84766/file/SOWC-1998.pdf

UNICEF. (2013). Improving Child Nutrition - The achievable imperative for global progress. United Nations Children's fund. In *Unicef*. https://docplayer.net/4825603-Improving-child-nutrition-the-achievable-imperative-for-global-progress.html

UNICEF. (2015). *Committing to Child Survival: A Promise Renewed Progress Report 2015*.

https://data.unicef.org/wp-content/uploads/2015/12/APR-2014-17Oct14-web_194.pdf

UNICEF. (2019a). National Situation Analysis of Children and Women in Ethiopia. *Unicef*, 138. https://www.unicef.org/ethiopia/reports/national-situation-analysis-children-and-women-ethiopia

UNICEF. (2019b). State of the World's Children 2019: Children, food and nutrition. In *Unicef*. https://www.unicef.org/media/63016/file/SOWC-2019.pdf

UNICEF. (2022). *Malnutrition in Children:UNICEF Data*. https://data.unicef.org/resources/resource-type/datasets/

UNICEF, WHO, & World Bank. (2020). Levels and trends in child malnutrition: Key findings of the 2020 Edition of the Joint Child Malnutrition Estimates. *Geneva: WHO*, *24*(2), 1–16.

United Nations. Department of International Economic and Social Affairs. (1985). *Socio-economic differentials in child mortality in developing countries*. United Nations.

United Nations. (1991). *Child mortality in developing countries : socio-economic differentials, trends, and implications*. United Nations.

United Nations. (2016). Arsenic and the 2030 Agenda for sustainable development. *Arsenic Research and Global Sustainability - Proceedings of the 6th International Congress on Arsenic in the Environment, AS 2016*, 12–14. https://doi.org/10.1201/b20466-7

United Nations Inter-agency Group for Child Mortality Estimation (UN IGME). (2020). *'Levels & Trends in Child Mortality: Report 2020, Estimates developed by the United Nations Inter-agency Group for Child Mortality Estimation', United Nations Children's Fund, New York, 2020.*

United Nations Inter-agency Group for Child Mortality Estimation (UN IGME). (2023). Levels & Trends in Child Mortality: Estimates developed by the United Nations Inter-agency Group for Child Mortality Estimation, 2022. In *UNICEF.org*. https://data.unicef.org/resources/levels-and-trends-in-child-mortality/

UNSD. (2022). The sustainable development goals report 2022. *United Nations Publication Issued by the Department of Economic and Social Affairs*, 1–64. https://unstats.un.org/sdgs/report/2022/extended-report/Extended-Report_Goal-3.pdf

USAID. (2018). Global Food Security Strategy (GFSS) Ethiopia Country Plan September 2018. *Feed the Future*, *September*, 21. https://www.usaid.gov/sites/default/files/documents/1867/Senegal_Country_Plan_WS_Edits.pdf

USAID. (2019a). *Feed the Future Ethiopia Country Strategy - April 2019*. https://2017-2020.usaid.gov/sites/default/files/documents/1867/GFSS-Country-Plan-Ethiopia-FINAL-April-2019.pdf

USAID. (2019b). *Pastoralists Areas Resilience Improvement and Market Expansion (PRIME) Project*. *March*, 20. https://pdf.usaid.gov/pdf_docs/PA00W978.pdf

USAID. (2021a). *Fact sheet: Northern Ethiopia Crisis*. *November 2020*, 2020–2021. https://www.usaid.gov/sites/default/files/2023-12/2023-09 30_USG_Northern_Ethiopia_Crisis_Fact_Sheet_5.pdf

USAID. (2021b). *Nutrition Profile Ethiopia*. *2020*(May 2021), 1–2. https://www.unicef.org/media/63016/file/SOWC-2019.pdf

USAID, & Mercy Corps. (2019). *Pastoralist Areas Resilience Improvement and Market Expansion (PRIME) Project. Final Report*. https://pdf.usaid.gov/pdf_docs/PA00WCWT.pdf

Victora, C. G., Barros, A. J. D., França, E. B., Victora, P. G., & Fleming, P. S. (2016). Socioeconomic inequalities in child mortality: a review of the evidence. The Lancet, 387(10023), 2324-2343. doi: 10.1016/S0140-6736(1630711-7)

Vollmer, S., Harttgen, K., Kupka, R., & Subramanian, S. V. (2017a). Levels and trends of childhood undernutrition by wealth and education according to a Composite Index of Anthropometric Failure: Evidence from 146 Demographic and Health Surveys from 39 countries. *BMJ Global Health*, *2*(2). https://doi.org/10.1136/bmjgh-2016-000206

Vollmer, S., Harttgen, K., Kupka, R., & Subramanian, S. V. (2017b). Levels and trends of childhood undernutrition by wealth and education according to a Composite Index of Anthropometric Failure: Evidence from 146 Demographic and Health Surveys from 39 countries. *BMJ Global Health*, *2*(2), 1–8. https://doi.org/10.1136/bmjgh-2016-000206

Wang, Y., Sibaii, F., Lee, K., J. Gill, M., & L. Hatch, J. (2021a). Inequities in childhood anaemia in Mozambique: results from multilevel Bayesian analysis of 2018 National Malaria Indicator Survey. *MedRxiv*, *165*, 1–13.

Wang, Y., Sibaii, F., Lee, K., J. Gill, M., & L. Hatch, J. (2021b). NOTE: This preprint reports new research that has not been certified by peer review and should not be used to guide clinical practice. 1. *MedRxiv*, *165*, 1–13.

WHO/UNICEF/WB. (2023). *Levels and trends in trends in Child malnutrition: Joint Child malnutrition estimates*. 1–32. https://www.who.int/publications/i/item/9789240073791

WHO. (2000). *The decline in child mortality: a\rreappraisal. Bull World Health Organ 2000*. *78*(00), 78, 1175–91.

WHO. (2001). *Iron deficiency anaemia*. https://cdn.who.int/media/docs/default-source/2021-dha-docs/ida_assessment_prevention_control.pdf?sfvrsn=fb8c459c_1&download=true

WHO. (2006). *WHO Child Growth Standards*. https://www.who.int/publications/i/item/924154693X

WHO. (2011a). Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. *Geneva, Switzerland: World Health Organization*, 1–6. https://doi.org/2011

WHO. (2011b). The global prevalence of anaemia in 2011. *Who*, 1–48. https://apps.who.int/iris/handle/10665/177094

WHO. (2013). *Handbook on health inequality monitoring: with a special focus on low- and middle-income countries*. https://www.who.int/docs/default-source/gho-documents/health-equity/handbook-on-health-inequality-monitoring/handbook-on-health-inequality-monitoring.pdf

WHO. (2020). *Children: Improving survival and well-being*. https://www.who.int/news-room/fact-sheets/detail/children-reducing-mortality

WHO. (2020a). **Social determinants of health**. https://www.who.int/health-topics/social-determinants-of-health; www.ucl.ac.uk/global-governance/sites/glob

WHO. (2021). *Underweight in children under 5 (JME) (UNICEF-WHO-WB) Available from*. https://www.who.int/data/gho/data/themes/topics/indicator-groups/indicator-group-details/GHO/gho-jme-global-and-regional-trends-underweight-jme-unicef-who-wb

WHO. (2022). *World health statistics 2022 (Monitoring health of the SDGs)*. http://apps.who.int/bookorders.

WHO. (2023a). *Accelerating anaemia reduction*.

https://iris.who.int/bitstream/handle/10665/367661/9789240074033-eng.pdf?sequence=1

WHO. (2023b). *World health statistics 2023: monitoring health for the SDGs, Sustainable Development Goals. Geneva: World Health Organization; 2023. Licence: CC BY-NC-SA 3.0 IGO.* https://reliefweb.int/report/world/world-health-statistics-2023-monitoring-health-sdgs-sustainable-development-goals?gclid=Cj0KCQjw7JOpBhCfARIsAL3bobeU7IN5vA97EFD5BYBp07SO_lB4tmERMrGAJQEFhwdaP_buafeO4LMaAmswEALw_wcB

WHO. (2023c). World health statistics 2023: monitoring health for the sdgs, sustainable development goals. In *The Milbank Memorial Fund quarterly* (Vol. 27, Issue 2).

Wijaya, O., Susanto, D. A., Heruwarsi, T., Giyanti, S., & Ibrahim, N. R. N. (2021). Decomposition of the Theil Index in Inequality Analyses in Yogyakarta Indonesia. *E3S Web of Conferences*, *316*, 02046. https://doi.org/10.1051/e3sconf/202131602046

Wolde, K. S., & Bacha, R. H. (2022). Trend and correlates of under-5 mortality in Ethiopia: A multilevel model comparison of 2000–2016 EDHS data. *SAGE Open Medicine*, *10*, 205031212211006. https://doi.org/10.1177/20503121221100608

Wondimu, H., & Dejene, K. (2022). Determinants of under-five malnutrition, significant changes, and policy implications in the Ethiopian Demographic Health Survey, 2019. *Discover Sustainability*, *3*(1). https://doi.org/10.1007/s43621-022-00087-6

Workie, S. B., Mekonen, T., Fekadu, W., & Chane Mekonen, T. (2020). <p>Level of Undernutrition and Its Determinants Among Children Aged 12–59 Months in Wolaita District, Ethiopia</p>. *Pediatric Health, Medicine and Therapeutics, Volume 11*, 109–117. https://doi.org/10.2147/phmt.s240906

World Bank. (2020a). *Ethiopia Poverty Assessment: Harnessing Continued Growth for Accelerated Poverty Reduction*. 1–288. www.worldbank.org

World Bank. (2020b). Ethiopia Regional Poverty Report. *Ethiopia Regional Poverty Report*. https://doi.org/10.1596/34805

World Bank. (2022). *Poverity and Equity Brief: Ethiopia*. *October 2022*. https://databankfiles.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/current/Global_POVEQ_ETH.pdf

World Bank (2022a). The state of child health inequalities link: https://www.rcpch.ac.uk/key-topics/child-health-inequalities-poverty

World Banks. (2014). *Ethiopia Poverty Assessment 2014*. https://documents.worldbank.org/curated/en/131011468247457565/pdf/AUS67440REVISE0sessment0pub02020015.pdf

World Health Organization (WHO) & International Center for Equity in Health. (2015), State of Inequality: Reproductive, Maternal and newborn and child health. https://www.who.int/docs/default-source/gho-documents/health-equity/state-of-inequality/state-of-inequality-reproductive-maternal-new-born-and-child-health.pdf

Wuneh, A. D., Bezabih, A. M., Okwaraji, Y. B., Persson, L. Å., & Medhanyie, A. A. (2022). Wealth and Education Inequities in Maternal and Child Health Services Utilization in Rural Ethiopia. *International Journal of Environmental Research and Public Health*, *19*(9). https://doi.org/10.3390/ijerph19095421

Yadav, J., & Nilima, N. (2021). Geographic variation and factors associated with anemia among underfives in India: A multilevel approach. *Clinical Epidemiology and Global Health*, *9*(September 2020), 261–268. https://doi.org/10.1016/j.cegh.2020.09.008

Yalew, M., Arefaynie, M., Bitew, G., Amsalu, E. T., Kefale, B., Muche, A., Fentaw, Z., Chanie, M. G., Melaku, M. S., Adane, B., Damtie, Y., Adane, M., Ayele, W. M., Andargie, A., & Dewau, R. (2022). Time to under-five mortality and its predictors in rural Ethiopia: Cox-gamma shared frailty model. *PLoS ONE*, *17*(4 April), 1–17. https://doi.org/10.1371/journal.pone.0266595

Yang, F., Liu, X., & Zha, P. (2018). Trends in Socioeconomic Inequalities and Prevalence of Anemia Among Children and Nonpregnant Women in Low- and Middle-Income Countries. *JAMA Network Open*, *1*(5), e182899. https://doi.org/10.1001/jamanetworkopen.2018.2899

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). https://doi.org/10.1186/s12889-019-6940-9

Yayo Negasi, M. (2021). Dynamics of inequality in child under-nutrition in Ethiopia. *International Journal for Equity in Health*, *20*(1), 1–30. https://doi.org/10.1186/s12939-021-01478-3

Yemane, G. D. (2022). The factors associated with under-five mortality in Ethiopia. *Annals of Medicine and Surgery*, *79*(May), 104063. https://doi.org/10.1016/j.amsu.2022.104063

Yohannes, M. A., Feleke, S. A., Mengesha, Z. B., & Workie, S. B. (2017). Childhood Mortality: Trends and Determinants in Ethiopia from 1990 to 2015—A Systematic Review. *Advances in Public Health*, *2017*, 1–10. https://doi.org/10.1155/2017/7479295

Yourkavitch, J., Burgert-Brucker, C., Assaf, S., & Delgado, S. (2018). Using geographical analysis to identify child health inequality in sub-Saharan Africa. *PLoS ONE*, *13*(8), 1–23. https://doi.org/10.1371/journal.pone.0201870

Zakaria, M., Tariq, S., & Iftikhar, M. (2019). *Socio-economic, macroeconomic, demographic, and environmental variables as determinants of child mortality in South Asia*. 954–964.

Zegeye, B., Ahinkorah, B. O., Ameyaw, E. K., Seidu, A. A., Keetile, M., & Yaya, S. (2021). Determining prevalence of anemia and its associated factors in Cameroon: A multilevel analysis. *BioMed Research International*, *2021*. https://doi.org/10.1155/2021/9912549

Zegeye, B., Shibre, G., Haidar, J., & Lemma, G. (2021). Socioeconomic, urban- rural and sex- based inequality in infant mortality rate: evidence from 2013 Yemen demographic and health survey. *Archives of Public Health*, *79*(1), 1–8. https://doi.org/10.1186/s13690-021-00589-1

Zegeye, B., Shibre, G., Idriss-Wheeler, D., & Yaya, S. (2021). Trends in inequalities in childhood stunting in Ethiopia from 2000 to 2016: A cross sectional study. *Journal of Public Health (United Kingdom)*, *43*(3), 655–663. https://doi.org/10.1093/pubmed/fdaa051

Zewudie, A. T., Gelagay, A. A., & Enyew, E. F. (2020). Determinants of Under-Five Child Mortality in Ethiopia: Analysis Using Ethiopian Demographic Health Survey, 2016. *International Journal of Pediatrics (United Kingdom)*, *2020*. https://doi.org/10.1155/2020/7471545

Zhihui, Li Mingqiang, L., Subramanian, S. V, & Lu, C. (2017). Assessing levels and trends of child health inequality in 88 developing countries : from 2000 to 2014. *Global Health Action*, *00*(00). https://doi.org/10.1080/16549716.2017.1408385

Zoran B, Gauss, C. H., Williams, D. K., & Hosmer, D. W. (2008). *Source Code for Biology and Purposeful selection of variables in logistic regression*. *8*, 1–8. https://doi.org/10.1186/1751-0473-3-17

Annexes

Annex I: Letter of Permission for Data Use

Apr 28, 2022

Negussie Tessema
Addis Ababa University
Ethiopia
Request Date: 04/28/2022

Dear Negussie Tessema:

This is to confirm that you are approved to use the following Survey Datasets for your registered research paper titled: "Trends in inequalities in child survival in Ethiopia: A two decade experience":

Ethiopia

To access the datasets, please login at: https://www.dhsprogram.com/data/dataset_admin/login_main.cfm. The user name is the registered email address, and the password is the one selected during registration.

The IRB-approved procedures for DHS public-use datasets do not in any way allow respondents, households, or sample communities to be identified. There are no names of individuals or household addresses in the data files. The geographic identifiers only go down to the regional level (where regions are typically very large geographical areas encompassing several states/provinces). Each enumeration area (Primary Sampling Unit) has a PSU number in the data file, but the PSU numbers do not have any labels to indicate their names or locations. In surveys that collect GIS coordinates in the field, the coordinates are only for the enumeration area (EA) as a whole, and not for individual households, and the measured coordinates are randomly displaced within a large geographic area so that specific enumeration areas cannot be identified.

The DHS Data may be used only for the purpose of statistical reporting and analysis, and only for your registered research. To use the data for another purpose, a new research project must be registered. All DHS data should be treated as confidential, and no effort should be made to identify any household or individual respondent interviewed in the survey. Also, be aware that re-distribution of any DHS micro-level data, either directly or within any tool/dashboard, is not permitted. Please reference the complete terms of use at: https://dhsprogram.com/Data/terms-of-use.cfm.

The data must not be passed on to other researchers without the written consent of DHS. However, if you have coresearchers registered in your account for this research paper, you are authorized to share the data with them. All data users are required to submit an electronic copy (pdf) of any reports/publications resulting from using the DHS data files to: references@dhsprogram.com.

Sincerely,

Bridgette Wellington

Bridgette Wellington
Data Archivist
The Demographic and Health Surveys (DHS) Program

Annex II: Approved Ethical Clearance Certificate

Addis Ababa University
አዲስ፡አበባ፡ዩኒቨርሲቲ

SEEK WISDOM, ELEVATE YOUR INTELLECT AND SERVE HUMANITY !

Approved

No: 004/02/2023

Ph.D. Proposal Ethical Clearance Certificate

1. **Student's name:** Negussie Shiferaw Tessema **Gender:** Male **Birth Date:** July 07/1978
   Id.No: GSR/9658/13 **e-mail:** ntshiferaw@gmail.com
2. **Home Center/Dep't: CoDS:** Center for Population Studies **Stream:** Population Studies
3. **PhD Dissertation Supervisor:**

   Prof. Nigatu Regassa **Email:** negyon@yahoo.com

5. **Title of the Proposal:** INEQUALITIES IN CHILD SURVIVAL IN ETHIOPIA: A TWO-DECADE EXPERIENCE
   - **Proposal No:** N.A. **Date accepted:** February 17, 2023
   - **Amendment No (if any):** N.A. **Date:** N.A.
4. **A clear statement of the decision:** The Academic Commission of the Center for Population Studies approved this PhD dissertation proposal. It is learnt from the request of the researcher and review of the approved proposal that, the study doesn't require fieldwork and it is planned to use EDHS dataset of Demographic Health survey (DHS) Program. It is confirmed that approval of DHS/ICF to use the dataset for this study through formal letter dated April 28, 2022 and granted access to the researcher. It is also clearly stated in the letter that the IRB of ICF approved procedures for DHS public use dataset do not allow study participants to be identified. As there are no names of participants in the data files, and the data may be used only for the purpose of statistical reporting and analysis for the registered researcher. With this background we found this proposal is qualified for ethical clearance.
5. **Decision:** As the study is using the dataset of DHS/ICF and approval is obtained with expected ethical use, CoDS/IRB hereby grants ethical clearance for this Ph.D. dissertation proposal.
6. **This certificate is issued upon the consent of:** IRB-CoDS.

IRB-CoDS

Name: Teshome Tafesse (Ph.D)

Designation: Chairperson of CoDS/IRB

E-mail: cods.irb@aau.edu.et

Signature: ....

Date: March 6, 2023

Addis Ababa University College of Development Studies Institutional Review Board (IRB)

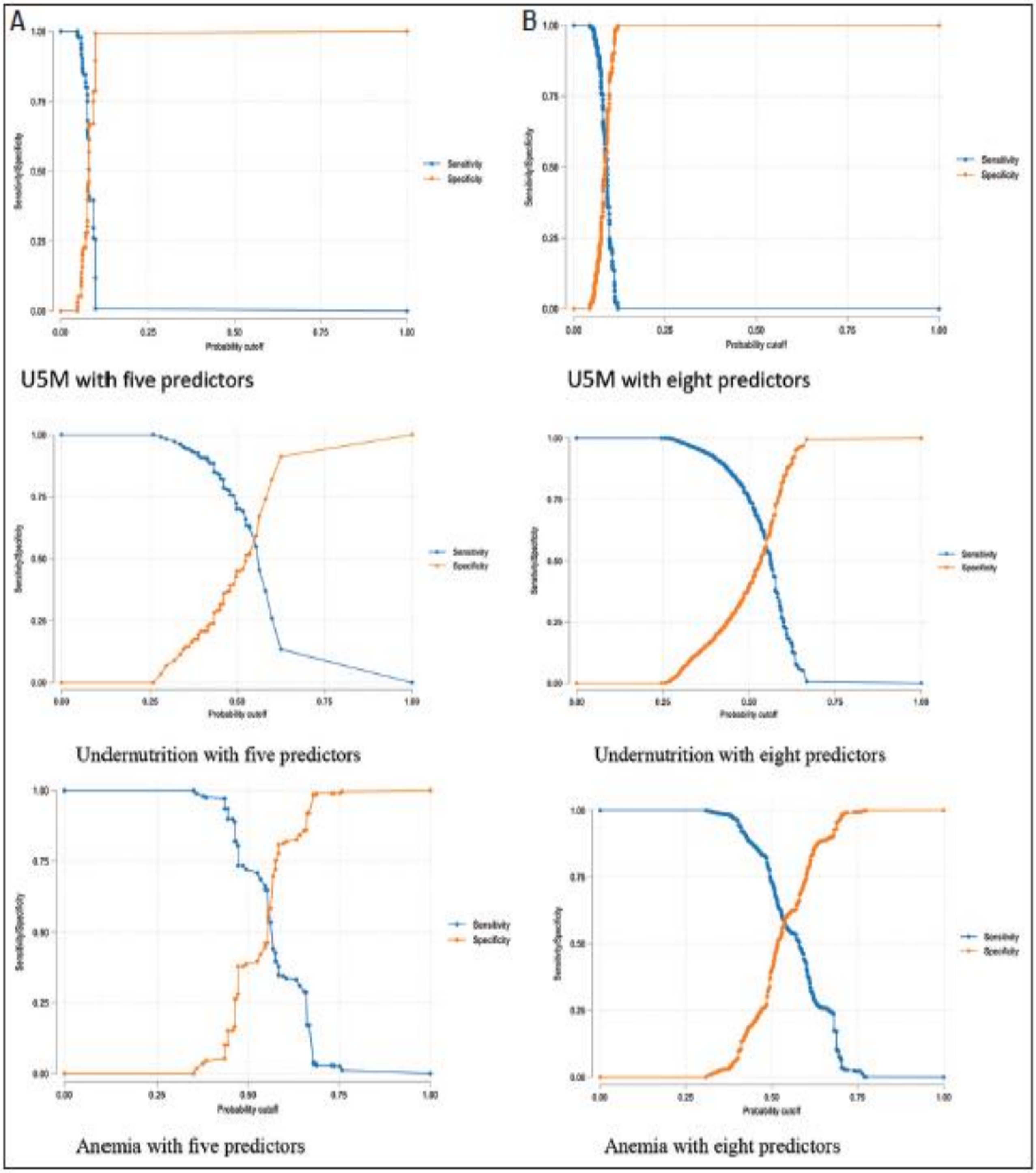
This certificate is valid only sealed and signed

Annex III: Dominance analysis of outcome with eight predictors in Ethiopia, 2000 - 2019

Inequality drivers	Dominance statistics	Standardized dominance statistics*	Ranking
Undernutrition (N=35,688)			
Region	0.0029	0.1083	4
Place of residence	0.0080	0.2985	2
Household wealth index	0.0057	0.2119	3
Maternal education	0.0083	0.3100	1
Child Sex	0.0005	0.0172	7
Religion	0.0005	0.0185	6
Sex of Household head	0.0000	0.0018	7
Employment status	0.0009	0.0338	5
Anemia (N=19,699)			
Region	0.0097	0.3329	1
Place of residence	0.0070	0. 2384	3
Household wealth index	0.0071	0.2452	2
Maternal education	0.0013	0.0452	6
Child sex	0.0001	0.0019	8
Religion	0.0017	0.0599	5
Sex of household head	0.0002	0.0007	7
Employment status	0.0021	0. 0709	4
Under-five mortality (N=48,422)			
Region	0.0001	0.0141	6
Place of residence	0.0013	0.1863	3
Household wealth index	0.0005	0.0792	5
Maternal education	0.0025	0.3627	1
Child sex	0.0016	0.2411	2
Religion	0.0000	0.0011	8
Sex of household head	0.0001	0.0127	7
Employment status	0.0007	0.1027	4

Note: *Standardized dominance statistics do not total to 1 due to rounding. Source: Ethiopia Demographic and Health Surveys: 2000, 2005, 2011, 2016, and 2019.

Annex IV: Dominance Sensitivity Analysis results



Annex V: Variance Inflation Factor analysis for childhood anemia

Table A1: Variance Inflation Factor

Explanatory variables	VIF	1/VIF
Birth order	1.776	.563
Place of residence	1.687	.593
Place of birth	1.604	.623
Household size	1.524	.656
Child age in months	1.504	.665
Duration of breastfeeding	1.493	.67
Maternal education	1.408	.71
Household wealth index	1.291	.774
Partner's education	1.289	.776
Region	1.247	.802
Maternal age at child birth	1.224	.817
Number of under-five in the HH	1.144	.874
Survey period	1.109	.902
Nutritional status of child	1.070	.935
Maternal anemia	1.063	.94
Maternal employment	1.062	.942
Sex of household head	1.041	.96
Child size at birth	1.040	.961
Child sex	1.011	.989
Mean VIF	1.294	.

Annex VI: Variance Inflation Factor analysis for under-five mortality

Table A2: Variance Inflation Factor for U5M analysis

Explanatory variables	VIF	1/VIF
Place of residence	2.06	0.485
Place of birth	1.61	0.621
Total children ever born	1.59	0.627
Household size	1.49	0.670
Type of toilet facility	1.44	0.692
Maternal education	1.44	0.695
Type of cooking fuel	1.38	0.725
Partner's education	1.38	0.727
Household wealth index	1.36	0.737
Regional category	1.32	0.758
Source of drinking water	1.31	0.761
Duration of breastfeeding	1.30	0.770
Child age in months	1.29	0.775
Region	1.12	0.895
Maternal age at child birth	1.11	0.899
Survey period	1.11	0.903
Maternal employment	1.05	0.949
Sex of household head	1.04	0.962
Child size at birth	1.03	0.967
Child sex	1.01	0.990
Mean VIF	1.32	.

Annex VII: The first page of the published and status of unpublished papers

ACCSCIENCE PUBLISHING

International Journal of Population Studies

RESEARCH ARTICLE

Exploring the most dominant drivers of inequalities in child survival in Ethiopia: Dominance analysis

Negussie Shiferaw Tessema[1]* and Nigatu Regassa Geda[2,3]

[1]Center of Population Studies, College of Development Studies, Addis Ababa University, Addis Ababa, Ethiopia

[2]College of Development Studies, Addis Ababa University, Addis Ababa, Ethiopia

[3]College of Pharmacy and Nutrition, University of Saskatchewan, Saskatoon, SK, Canada

Abstract

Inequalities in child survival are a global public health concern. Over the past decade, Ethiopia has made remarkable progress in improving child survival. Despite this promising development, inequalities in child survival among the various population groups remained a pressing public health concern. The purpose of this paper is to examine the dominant drivers of inequality in child survival indicators (undernutrition, anemia, and under-five mortality) in Ethiopia. Dominance analysis was used based on a pooled total sample of 48,422 under-five children drawn from five rounds of Ethiopia Demographic and Health Surveys conducted from year 2000 to 2019. Childhood undernutrition, childhood anemia, and under-five mortality were the three outcome variables, and the five dimensions of inequality were considered as key predictor variables. The dominance analysis revealed that maternal education, place of residence, and household wealth index were the three most dominant drivers of inequalities in childhood undernutrition, accounting for 83.48% of the predicted variances. The regional category was found to be the first-ranked key driver of inequalities in childhood anemia, accounting for 50.56% of the predicted variance. The dominance analysis also indicated that maternal education, child sex, and place of residence were the three most dominant drivers of inequality in under-five mortality, accounting for 89.3% of the predicted variance. This study provides empirical evidence that maternal education (individual level), household asset based wealth index (household level), and place of residence (community level) were the most dominant drivers of inequality in child survival. This suggests interventions in reducing inequalities in child survival need to start at the community level, notwithstanding the importance of household and individual level influences.

Keywords: Dominant drivers; Dominance analysis; Inequalities; Child survival; Under-five mortality; Ethiopia

***Corresponding author:**
Negussie Shiferaw Tessema
(ntshiferaw@gmail.com)

Citation: Negussie S.T., & Nigatu R.G., (2023). Exploring the most dominant drivers of inequalities in child survival in Ethiopia: Dominance analysis. *International Journal of Population Studies*.
https://doi.org/10.36922/ijps.427

Received: December 19, 2022

Accepted: March 29, 2023

Published Online: April 14, 2023

1. Introduction

1.1. Background

Inequalities in child survival are a global public health concern (Brault *et al.*, 2020; Cha & Jin, 2020). Although reducing inequalities in child survival are given due attention

Discover Social Science and Health

Research

Levels and trends in key socioeconomic inequalities in childhood undernutrition in Ethiopia: evidence from Ethiopia demographic and health surveys 2000-2019

Negussie Shiferaw[1] · Nigatu Regassa[1]

Received: 29 November 2022 / Accepted: 17 February 2023
Published online: 09 March 2023

Abstract

Introduction The global burden of childhood undernutrition is mainly concentrated in low-income and lower-middle-income countries. In Ethiopia, childhood undernutrition varies significantly across different population groups. The present study is aimed at examining the levels and trends in key socioeconomic inequalities in childhood undernutrition in Ethiopia.

Methods This cross-sectional study was based on a total pooled sample of 48,782 under-five children drawn from five rounds of the Ethiopia Demographic and Health Surveys (2000–2019). We used multilevel binary logistic regression analysis to determine the key socioeconomic determinants of undernutrition among under five children. In addition, we applied concentration index and decomposition rate analysis techniques to explore the levels and trends in key socioeconomic inequalities in childhood undernutrition.

Results Place of residence, household wealth status (approximated by asset-based wealth index), and maternal education, among others, were the key socioeconomic variables significantly associated ($p < 0.001$) with childhood undernutrition in Ethiopia. The level of inequality was the highest with children from rural areas, poor households and uneducated mothers. Absolute socioeconomic inequality in childhood undernutrition prevalence rate was declined by 9.72 during the study period (2000 to 2019).

Conclusion Childhood undernutrition was unequally distributed among under-five children in Ethiopia, and largely concentrated among low socioeconomic status population groups. The identified key socioeconomic drivers of inequality in childhood undernutrition can be used to inform localized interventions and communication strategies to improve nutritional status of under-five children in Ethiopia. The study underscores development of poverty reduction strategies that directly address the existing challenges of the food insecurity and childhood undernutrition for the low-income population groups in the country.

Keywords Childhood · Levels · Inequalities · Trends · Undernutrition · Ethiopia

Abbreviations

AIC	Akaike's information criteria
BIC	Bayesian information criteria
CSA	Central statistical agency
DHS	Demographic and health survey

✉ Negussie Shiferaw, ntshiferaw@gmail.com | [1]Center of Population Studies, College of Development Studies, Addis Ababa University, Addis Ababa, Ethiopia.

Discover Social Science and Health

Discover

Research

Trends in regional inequalities in childhood anemia in Ethiopia: evidence from the 2005–2016 Ethiopian Demographic and Health Surveys

Shiferaw Tessema Negussie[1] · Regassa Geda Nigatu[1,2]

Received: 10 January 2023 / Accepted: 22 March 2023
Published online: 30 March 2023

Abstract

Introduction Globally, 269 million children aged 6–59 months were anemic in 2019. Of these, 103 million anemic children were from Africa. Childhood anemia is still a serious public health concern in SSA countries, including Ethiopia. In Ethiopia, the prevalence of childhood anemia largely varies by geographic administration regions. This study is aimed to examine trends in regional inequalities in childhood anemia in Ethiopia over the period 2005–2016.
Method This cross-sectional study was based on a pooled total sample of 17,766 children aged 6–59 months drawn from three rounds of the Ethiopian Demography and Health Surveys (2005–2016). We employed multilevel binary logistic regression analysis to identify the determinants of childhood anemia among children aged 6–59 months. We also used Theil and multivariate decomposition analyses to examine the levels and trends in relative regional inequalities in childhood anemia.
Result A combination of individual-, household- and community-level factors were significantly (p < 001) associated with childhood anemia. From the pooled data, the highest childhood anemia was observed in Somali (78.68%) followed by Afar region (72.76%) while the lowest childhood anemia was in Amhara (41.01%), Addis Ababa (42.64%) and SNNPR (44%) between 2005 and 2016. The total relative inequality declined from 0.620 in 2005 to 0.548 in 2016. Overall, one-third of change in regional inequalities in childhood anemia was due to the differential resulted from the difference in observable characteristics of the subjects.
Conclusion Overall progress made in Ethiopia was very slow with only a 13.14% reduction in the relative regional inequalities in childhood anemia over 11 years. The present study underscores addressing the existing disparities in socio-economic status, maternal anemia and maternal employment status between emerging and non-emerging regions to reduce regional inequality in childhood anemia.

Keywords Anemia · Childhood · Decomposition · Inequalities · Regional · Trends · Ethiopia

Abbreviations

AIC	Akaike's Information Criteria
BIC	Bayesian Information Criteria
CSA	Central Statistical Agency
DHS	Demographic and Health Survey
EDHS	Ethiopia Demographic and Health Survey

✉ Shiferaw Tessema Negussie, negut2016@gmail.com; Regassa Geda Nigatu, negyon@yahoo.com | [1]Center of Population Studies, College of Development Studies, Addis Ababa University, Addis Ababa, Ethiopia. [2]College of Pharmacy and Nutrition, University of Saskatchewan, Saskatoon, SK, Canada.

ACCSCIENCE PUBLISHING

International Journal of Population Studies

RESEARCH ARTICLE

Residential inequalities in child mortality in Ethiopia: Multilevel and decomposition analyses

Negussie Shiferaw Tessema*, Chalachew Getahun Desta, Nigatu Regassa Geda, and Terefe Degefa Boshera

Center for Population Studies, College of Development Studies, Addis Ababa University, Addis Ababa, Ethiopia

Abstract

Ethiopia is among the five countries which account for half of the global under-five deaths, with the under-five mortality rate of 67 deaths/1000 live births in 2016. Ethiopia had significant inequalities in child mortality between rural and urban areas where the risk of child mortality is largely higher in rural than urban areas. Inequalities in the distribution of factors influencing child mortality need to explain the gap between and within urban-rural areas. The study used the risk of child mortality as an outcome variable. Multilevel logistic regression was used as a standard model for assessing the effect of socioeconomic and contextual factors on child mortality. Furthermore, the Blinder-Oaxaca decomposition technique was used to explain the urban-rural, intra-rural, and intra-urban inequalities in child mortality. The birth order and sanitation type seem to be the most important explanatory factors, followed by wealth status in explaining the rural-urban inequality of 39 deaths/1000 children. Mean proportion indicates that there would be 47 deaths/1000 children for urban poor and 21 deaths/1000 children for urban non-poor, resulting in 26 deaths/1000 children change in urban poor when applying the urban non-poor coefficient and characteristics to urban poor behavior. The findings showed that some residential inequalities in child mortality occur at a level that could be addressed by targeting children, households, and some occurs at a community level that could be addressed by targeting regions. Therefore, any residential sensitive and specific interventions should consider child's and household's characteristics, and geographical location.

Keywords: Child mortality; Inequality; Residence; Intra-rural; Intra-urban; Rural-urban; Ethiopia

***Corresponding author:**
Negussie Shiferaw Tessema
(ntshiferaw@gmail.com)

Citation: Negussie S.T., Chalachew G.D., Nigatu R.G., & Terefe D. B., (2021). Residential inequalities in child mortality in Ethiopia: Multilevel and decomposition analyses. *International Journal of Population Studies*, 7(2):47-59.
https://doi.org/10.36922/ijps.v7i2.392

Received: October 11, 2022

Accepted: November 18, 2022

Published Online: December 16, 2022

1. Introduction

Inequality in child mortality is a global priority. Socioeconomic inequality in child mortality has been a concern of the United Nations since the adoption of the World Population Plan of Action in 1974 and its implementation agreed on at the International Conference on Population in 1984 (United Nations, 1991). The 1984 International Conference on Population strongly urged all governments, regardless of the mortality levels of their population to reduce mortality levels and socioeconomic and geographical differentials in their countries and to improve health among all population groups, especially among those groups where the mortality levels are the highest (United Nations.

SPRINGER NATURE SNAPP | Discover Social Science and Health

Account

Trends in Maternal Education-based Inequalities in Under-five Mortality in Ethiopia: Multilev...

CURRENT STATUS

Your submission has passed technical checks

The editors' decision can take several weeks as they may consult peer reviewers.

We will email ntshiferaw@gmail.com if there are any revisions you need to make.

Need help?

If you have any questions about this submission, you can email the Editorial Office.

How was your experience today?

Awful Bad OK Good Great

Send feedback

Progress so far

Show history

- Submission received
- Initial technical check
- Peer review

Your submission

Title

Trends in Maternal Education-based Inequalities in Under-five Mortality in Ethiopia: Multilevel, Decomposition and Concentration Index Analyses

Type

Research

Journal

Discover Social Science and Health

Submission ID

f6147817-b64f-43c3-a62d-

SPRINGER NATURE SNAPP | BMC Pediatrics

Account

Population Level Impacts of Risk Factors of Childhood Anemia, Undernutrition, and Under-five ...

CURRENT STATUS

Your submission has passed the technical checks and is now in peer review

We will now find the most suitable editor to manage the next steps of your submission. If your submission is successful, they will invite reviewers to peer review your work. This process can take a few weeks.

We will email ntshiferaw@gmail.com if there are any revisions you need to make.

Need help?

If you have any questions about this submission, you can email the Editorial Office.

For general enquiries, please look at our support information.

Progress so far

Show history

- Submission received
- Initial technical check
- Peer review

Your submission

Title

Population Level Impacts of Risk Factors of Childhood Anemia, Undernutrition, and Under-five Mortality in Ethiopia

Type

Research

Journal

BMC Pediatrics

Submission ID

8bead9e6-9b5d-4a62-9bcb-ef734ddfd32d

SPRINGER NATURE SNAPP | Journal of Health, Population and Nutrition | Account

Spatial Variability of Child Survival in Ethiopia: Evidence from Nationally Representative Surveys

CURRENT STATUS

Your submission has passed the technical checks and is now in peer review

We will now find the most suitable editor to manage the next steps of your submission. If your submission is successful, they will invite reviewers to peer review your work. This process can take a few weeks.

We will email ntshiferaw@gmail.com if there are any revisions you need to make.

Need help?

If you have any questions about this submission, you can email the Editorial Office.

For general enquiries, please look at our support information.

Progress so far

Show history

- Submission received
- Initial technical check
- Peer review

Your submission

Title
Spatial Variability of Child Survival in Ethiopia: Evidence from Nationally Representative Surveys

Type
Comment

Journal
Journal of Health, Population and Nutrition

Submission ID
707d64de-5613-4d67-8112-13963e1af388