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Tefera Darge Delbiso has been working as a research associate at CRED since 2014. Prior to that, he was a research advisor in Marie Stops International Ethiopia, a lecturer at Hawassa University-Ethiopia, and an independent consultant. He holds BSc in Statistics and MSc in Population Studies from Addis Ababa University, and specialized Master in Public Health Methodology from ULB–Belgium. His current research focuses on improving public health needs assessment in humanitarian emergencies.

Comprehensive analysis of the impact of humanitarian emergencies on nutrition and mortality is limited in Ethiopia. This is mainly due to either the lack of nationally representative data or non-generalizability of subnational health surveys in such settings. Consequently, humanitarian decisions and advocacy are often based on anecdotal information or non-representative data with limited geographical coverage. The aims of this study are therefore to investigate the burden of malnutrition and mortality, and to identify its causes in humanitarian settings. Given the data challenges, we apply advanced epidemiological methods in existing population-based health surveys. The key findings are: i) the burden of child undernutrition is declining, but are persistent and higher in moderate drought areas; ii) the burden of child mortality falls below both the emergency and baseline thresholds for sub-Saharan Africa; iii) the burden of women's undernutrition is higher near the borders. On the basis of these findings, we provide propositions to guide effective humanitarian interventions.

En Ethiopie, l'analyse approfondie de l'impact des situations d'urgence humanitaire sur la nutrition et la mortalité reste limitée. Ceci est dû soit à un manque de données représentatives au niveau national, soit à la non généralisation d'enquêtes de santé au niveau sous-national dans un contexte de crise. Par conséquent, les décisions humanitaires et plaidoyers sont souvent basés sur des informations et données non-représentatives ayant une couverture géographique limitée. Les objectifs de cette étude visent dès lors à examiner le fardeau de la malnutrition et de la mortalité ainsi qu'à identifier ses causes lors de situations d'urgence. Etant donné les difficultés liées aux données, nous avons appliqué des méthodes épidémiologiques avancées à partir d'enquêtes existantes sur la santé des populations. Les principales conclusions sont : i) le fardeau de la malnutrition infantile est en baisse, mais persiste et est plus important dans des zones de sécheresse modérée; ii) le fardeau de la mortalité infantile est en dessous du seuil d'urgence et de référence pour l'Afrique subsaharienne ; iii) le fardeau de la dénutrition chez les femmes est plus important dans les zones frontalières. Sur base de ces conclusions, nous fournissons des propositions afin de guider de manière efficace les interventions humanitaires.

The burden of malnutrition and mortality in humanitarian emergencies 2018 Tefera Darge Delbiso

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Centre for Research on the Epidemiology of Disasters CRED

The burden of malnutrition and mortality in humanitarian emergencies

Efficient use of health surveys from Ethiopia

Tefera Darge Delbiso

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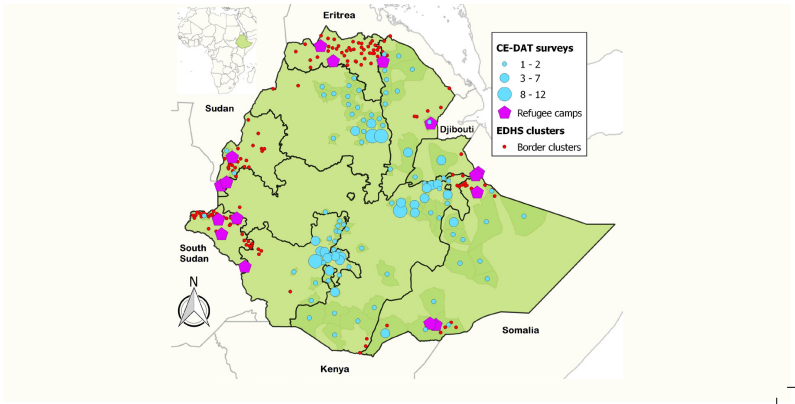

The burden of malnutrition and mortality in humanitarian emergencies

Efficient use of health surveys from Ethiopia

Tefera Darge Delbiso

Promoter:
Prof. Debarati Guha-Sapir

Thesis submitted in fulfillment of the requirements for the degree of
Doctor in Public Health

Centre for Research on the Epidemiology of Disasters, CRED
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Université catholique de Louvain, UCL
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"*Without good data, we're flying blind. If you can't see it, you can't solve it.*"

– – – Kofi Annan, 2018

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This thesis is dedicated to my late mother,

Elfenesh Wakera (Eteye).

She would have been so proud.

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List of Abbreviations

ACLED	Armed Conflict Location & Event Data
ADLI	Agricultural Development Led Industrialization
AU	African Union
BMI	Body Mass Index
CDR	Crude Death Rate
CE-DAT	Complex Emergency Database
CMAM	Community Management of Acute Malnutrition
CRED	Center for Research on the Epidemiology of Disasters
CRVS	Civil Registration and Vital Statistics
CrI	Credible Interval
CUD	Coalition for Unity and Democracy
DHS	Demographic and Health Surveys
DIC	Deviance Information Criterion
DRMFSS	Disaster Risk Management and Food Security Sector
DRR	Death Rate Ratio
EDHS	Ethiopian Demographic and Health Surveys
EM-DAT	International Disaster Database
ENA	Emergency Nutrition Assessment
ENCU	Emergency Nutrition Coordination Unit
EOS	Enhanced Outreach Strategy
EPI	Expanded Programme on Immunization
EPRDF	Ethiopian Peoples' Revolutionary Democratic Front
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
FEWS NET	Famine Early Warning Systems Network
FNRS	Fond National de Recherche Scientifique
FSP	Food Security Program
GAM	Global Acute Malnutrition
GDP	Gross Domestic Product
GED	Georeferenced Events Dataset
GIS	Geographic Information Systems
GPS	Geographic Coordinate System
GTP	Growth and Transformation Plan
HAB	Household Asset Building
HDSS	Health and Demographic Surveillance System
HDI	Human Development Index
HEP	Health Extension Program
HSDP	Health Sector Development Program

IASC	Inter-Agency Standing Committee
ICCM	Integrated Community Case Management
ICU	Islamic Court Union
IPC	Integrated Food Security Phase Classification
MAM	Moderate Acute Malnutrition
MDG	Millennium Development Goal
MCMC	Markov Chain Monte Carlo
MCV	Measles-containing Vaccine
MICS	Multiple Indicator Cluster Surveys
NCHS	National Center for Health Statistics
NGO	Non-governmental Organization Organization
ONLF	Ogaden National Liberation Front
OLF	Oromo Liberation Front
OR	Odds Ratio
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty
PDSI	Palmer's Drought Severity Index
PPS	Probability Proportional to Size
PSNP	Productive Safety Net Program
PSU	Primary Sampling Unit
SAM	Severe Acute Malnutrition
SDG	Sustainable Development Goal
SDPRP	Sustainable Development and Poverty Reduction Program
SMART	Standardized Monitoring and Assessment of Relief and Transitions
SNNP	Southern Nations, Nationalities and Peoples'
SPEI	Standardized Precipitation and Evapotranspiration Index
SPI	Standardized Precipitation Index
TGE	Transitional Federal Government
TPLF	Tigray People's Liberation Front
UCDP	Uppsala Conflict Data Program
UCL	Université catholique de Louvain
UEDF	United Ethiopian Democratic Forces
UN	United Nations
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
USD	United States Dollars
U5DR	Under-five Death Rate
U5MR	Under-five Mortality Rate
WHO	World Health Organization

Summary

In the last quarter-century, considerable progress has been made in improving the lives of billions around the world. In recent years, however, humanitarian emergencies are threatening these progress through averting poverty reduction efforts, increasing the global food-insecure people, and stagnating infant mortality reduction, among others. Humanitarian emergencies, particularly recurrent droughts and violent conflicts, are widely prevalent in Ethiopia, but comprehensive analysis of their impact on nutrition and mortality is limited. This is largely due to either the lack of nationally representative data or non-generalizability of subnational health surveys in such settings. Consequently, humanitarian decisions and advocacies are often based on anecdotal information or non-representative data with limited geographical coverage. Despite calls for more data, thorough investigation of existing national and subnational population-based health surveys could provide evidence to guide effective response and preparedness efforts thereby increasing the return on investment of the surveys. On this basis, we apply meta-analysis and multilevel modelling in available health surveys to investigate the burden of malnutrition and mortality, and to identify its causes in humanitarian settings in Ethiopia. Despite an overall declining trend, the burden of child undernutrition is persistent and higher in moderate drought-affected areas. However, the burden of child mortality falls below both the emergency and baseline thresholds of sub-Saharan Africa. We also found an elevated burden of women's undernutrition among border residents. Nutrition interventions should incorporate areas where moderate droughts occur. Targeting the border communities through improved sanitation and household economies are essential to enhance their livelihoods and eventually women's nutritional status. The study also highlights the need to review and update the existing mortality thresholds. Albeit we found no association between conflict and child undernutrition, and between drought and child mortality, the mitigation efforts should not downplay the adverse health effects of these events.

Chapter 1

Public Health in Humanitarian Emergencies: An Overview

In this chapter, first we define humanitarian emergencies and introduce its human cost. Second, we discuss the conceptual frameworks in which the study is based upon. Third, we review the challenges and prospects in obtaining reliable data to help improve humanitarian decision-making. Finally, we provide a detailed outline of the aims of the study together with the thesis outline.

1.1 What are Humanitarian Emergencies?

According to the United Nations (UN) Inter-Agency Standing Committee (IASC) definition, a complex emergency is a humanitarian crisis which occurs in a country, region, or society where there is a total or considerable breakdown of authority resulting from internal or external conflicts and which requires an international response that goes beyond the mandate or capacity of any single agency and hence requires intensive and extensive political and management coordination [1]. Similarly, the World Health Organization (WHO) defines complex emergencies as "situations of disrupted livelihoods and threats to life produced by warfare, civil disturbance and large-scale movements of people, in which any emergency response has to be conducted in a difficult political and security environment" [2].

In general, humanitarian emergencies arise when events, such as armed conflicts, natural disasters, and epidemics, produce a critical threat to the health, safety, security or well-being of people. They usually characterized by violence and loss of life, displacements of populations, widespread damage to the societies and economies, failure of the state to mitigate the threats, need for large-scale urgent life-saving humanitarian assistance, and security risk for humanitarian workers [1, 2]. Their impact is heavy among vulnerable groups, including children, pregnant and nursing women, migrants and displaced people. In this thesis, we consider humanitarian emergencies arising from violent conflicts and natural disasters (particularly, droughts) which cause food insecurity, induce displacement and threaten livelihoods thereby exacerbating malnutrition and mortality.

1.2 The Cost of Humanitarian Emergencies: The Global Context

Over the last quarter-century, notable progress has been made in improving the lives of billions of people around the world, particularly in low- and middle-income countries. Accordingly, extreme poverty [3], undernourishment [4], child stunting [5], child mortality [6] and maternal mortality [7] have reduced substantially; and life expectancy has

increased [3]. The progress was mainly driven by the unprecedented efforts through different initiatives, such as the Millennium Development Goals (MDGs), supported by consistent funding for health.

Nonetheless, in recent years, humanitarian emergencies are threatening the advancement made so far. Despite a considerable success in eradicating hunger, for example, the global food-insecure people have been on the rise since 2014. The ongoing and chronic conflicts (e.g., Afghanistan, the Democratic Republic of the Congo (DRC), and Somalia) and newly emerged ones (e.g., Syria, South Sudan, and Yemen) compounded with natural disasters (particularly, prolonged droughts and severe floods) contributed to this deterioration [4, 8]. In 2016, about 60% of the global food-insecure people and 75% of the global stunted children lived in conflict-affected countries [4, 5]. In Africa, for example, among fourteen countries in protracted crisis situations in 2016, eleven were in a state of food insecurity [4]; and the continent bears over 80% of the global climate-induced acute food-insecure people in 2017 [8]. Indeed, none of the countries in protracted crisis and fragility situations achieved the MDG target of reducing hunger by half [9] and they will face a huge setback in achieving the Sustainable Development Goals (SDGs) as well. Furthermore, the MDG target of a two-thirds reduction in child mortality was not met according to schedule; it would take additional 10 or more years if the current trend continues [10]. This requires additional urgency to accelerate the pace of improving child survival; otherwise, 69 million children will die before celebrating their fifth birthdays during the SDG period, 2015–30 [10]. In this regard, the majority of child mortality occurs in humanitarian settings: 53% of all under-five deaths and 45% of all neonatal deaths [11]. Overall, the chance of dying for children in fragile settings is twice that of children in stable situations [6].

Hence, the health needs of people in humanitarian settings require more attention than ever before as humanitarian crises are likely to continue in the future [4, 12, 13]. Acknowledging this fact, the 2030 SDGs agenda, unlike its predecessor MDGs, gives more emphasis to the needs of the most vulnerable groups, including those affected by natural disasters, conflicts, climate change and forced displacement. Some of the

targets include SDG 1 target 1.5 "*build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social, and environmental shocks and disasters*" and SDG 16 target 16.1 "*significantly reduce all forms of violence and related death rates everywhere*" [14].

1.2.1 The human impact of natural disasters

Natural disasters are situations or events which cause great damage and destruction to the environment, induce human suffering and overwhelm the local capacity thereby necessitating a request for national or international assistance. They are broadly classified into three groups: biological disasters (e.g., epidemics and insect infestation), geophysical disasters (e.g., earthquakes and volcanic activities), and climate-related disasters – hydrological (e.g., floods and landslides), meteorological (e.g., storms and extreme temperatures) and climatological (e.g., droughts and wildfires) disasters [15–17]. They can also be classified as either rapid-onset disasters, such as earthquakes and floods, or slow-onset disasters, such as droughts. Their impact is heavy in low- and middle-income countries, where resources, infrastructures, and disaster-preparedness plans are restraints [16, 18].

Natural disasters can affect human health in different ways, be it through directly or indirectly. In the former case it increases injuries and deaths, damages the physical health infrastructures, overloads the health systems and stresses the health care providers; while in the latter case it disrupts the regular living conditions, affects crop and livestock productions, coerces people to flee their residence, and destructs services, including water supply, electricity, and transportation [19]. Disease outbreaks are evident in the aftermath of natural disasters, mainly due to population displacement that often results in poor access to safe water and sanitation, and inadequate shelter and healthcare services. The impact of natural disasters stays for long, both in the physical, biological and social environments, and in the lives and well-being of the affected populations [18, 19].

According to the International Disaster Database (EM-DAT; [17]), between 1990 and 2015, a total of 9,689 natural disasters hit the world.

Every year, on average, about 201 million people were affected, about quarter of a million were injured, and about 70,000 were killed. The Food and Agriculture Organization of the United Nations (FAO) estimate shows that, between 2005 and 2014, natural disasters caused about 23% of damages and losses to the agricultural sector in developing countries, which corresponds to 93 billion United States Dollars (USD) [20]. The number of disasters has shown a sharp increase between the mid-1990s and early 2000s and then rose once again in mid-2000s, before starting to decline slowly (Figure 1.1). Similarly, population affected by disasters was the highest in the mid-1990s, and showed an additional peak at the end of 2000s following the 2008 cyclone Nargis and the 2010 Haiti earthquake [16]. Thereafter, the trend showed a sharp decline. On the other hand, disaster-induced deaths were the highest in the mid-2000s following the Indian Ocean Tsunami [16] and then started declining (Figure 1.1).

Droughts, following floods, are the second top-ranked natural disasters in terms of population impact. Over the period 1990–2015, a total of 417 droughts occurred worldwide and affected about 49.8 million people per year, on average. The drought effect peaked in the early 2000s (Figure 1.1) mainly due to the 2001–03 droughts in Southern and Southeastern Africa [21], and the 2002 Indian drougt which affected 300 million people [16]. Then it declined sharply until the mid-2000s and then started increasing slowly and steadily (Figure 1.1). Africa suffered more frequent droughts than any other continents: 167 droughts (40% of all drought events globally) hit the continent and affected more than 11 million each year, on average. Consequently, the continent lost up to 20% of its agricultural production (amounted to more than 17 billion USD) between 2005 and 2014 [20]. The drought toll was the strongest in Eastern Africa, where 90 droughts occurred (over 50% of all droughts in Africa) and affected about 7.5 million people every year (nearly 68% of all drought victims in Africa). Following the devastating impact of El Niño weather events in 2015–16, particularly in Eastern and Southern Africa, Central America, and the Caribbean, the trend of drought victims is expected to rise [8, 22].

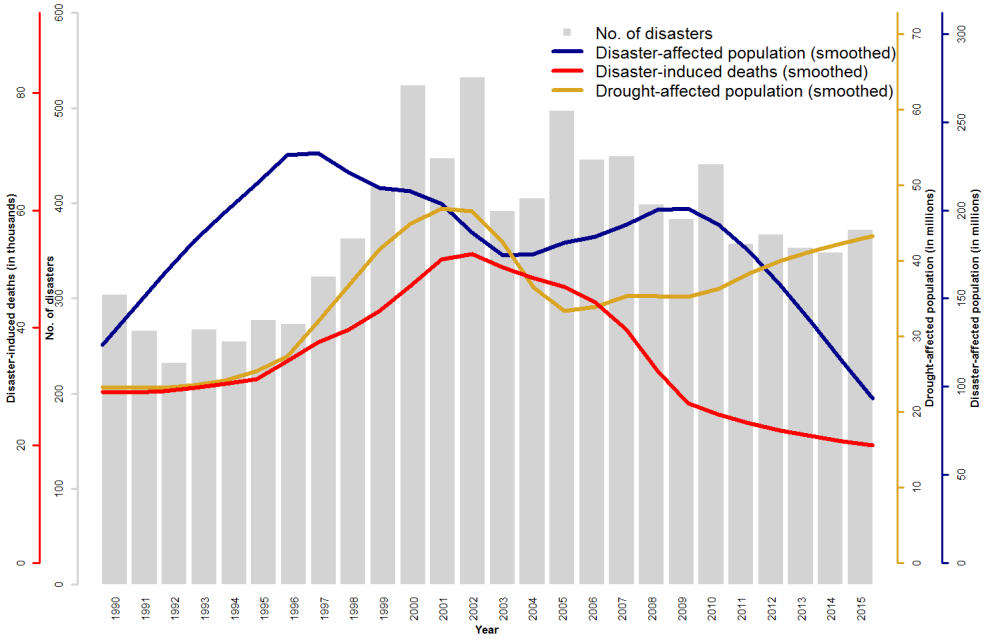

FIGURE 1.1: **Levels and trends of natural disasters, population affected and died in the world, 1990–2015.** The disaster data was obtained from the EM-DAT (http://www.emdat.be/; [17]). To be recorded in EM-DAT, a disaster event must meet at least one of the following four criteria: i) ten or more people reported killed; ii) 100 or more people reported affected; iii) declaration of a state of emergency; iv) call for international assistance. In EM-DAT, total deaths include persons confirmed as dead and persons missing and presumed dead, excluding indirect deaths from diseases, epidemics and other effects which occur after the emergency phase of the disaster. Total affected include people suffering physical injuries, trauma or an illness that requires medical treatment as a direct result of a disaster; people requiring immediate assistance during a period of emergency, including displaced or evacuated people; and homeless people needing immediate assistance for shelter. For better visibility of the trends, we smoothed the data using local regression methods.

1.2.2 The human impact of conflicts

Conflict and political instability damages livelihood, robes human dignity, devastates the economy, destroys infrastructure, compromises the overall development and drags individuals and nations into deep poverty [15, 23, 24]. According to the 2011 world development report, more than 1.5 billion people (about 21% of the world population) have lived

in countries affected by repeated cycles of conflicts [24]. Indeed, conflict and instability are widely prevalent in resource-poor settings [25]. Poor governance and underdevelopment are the underlying causes, but also the consequences of conflict. In addition, climate change, land degradation, and water scarcity intensify conflicts [23–25].

Conflict contributes to public health crises directly by creating excess injury and mortality, and indirectly by sustaining poverty, affecting food security, triggering population displacement, and destroying health and social services [26]. For example, more than 80% of excess deaths in the Darfur conflict between 2003 and 2008 were due to conflict-aggravated diseases, such as diarrhea; and displaced populations were at higher risk for these conditions [27]. Had the crisis not happened, life expectancy in Syria, between 1990 and 2013, would have been 6 and 5 years higher than the observed for men and female, respectively [12]. Furthermore, the Syrian crisis averted the infant mortality reduction efforts; the annualized rate of reduction in infant mortality dropped below zero between 2010 and 2013 compared to what it has been before 2010 [12]. Conflict severely hampers poverty reduction efforts as well; for every three years a country affected by a major violent conflict, poverty reduction lags behind by 2.7% [24]. Similarly, in 2010–12, nearly 40% of the population in countries going through protracted crises were food-insecure compared to only 15% in the rest of the developing world [28]. Overall, achieving most of the MDGs was jeopardized in conflict-affected countries [24].

The impact of conflict is more pronounced among vulnerable groups, including children, pregnant women, disabled persons and the elderly. For instance, children born in regions affected by civil conflict in Rwanda showed a higher level of chronic malnutrition [29]. Likewise, among civilians who died in the Syrian crisis, on average, one in five were children [30]. Overall, more than half of the countries with the highest under-five mortality rates (U5MR) in the world are those affected by conflict or in fragile situations [31].

Over the last 26 years, 1990–2015, a total of 125,901 organized violence (phenomena of lethal violence occurring at a given time and

place) data were recorded in the Uppsala Conflict Data Program (UCDP) Georeferenced Events Dataset (GED) [32, 33]. Despite a sporadic increase in the number of organized violence events in the world, violence-related deaths have been stable at the lower level after the huge peak during the 1994 Rwanda genocide and the slight rise during the 1998–2000 Eritrea-Ethiopia war (Figure 1.2). The decline in violence-related deaths is mainly due to the success in reducing intense conflicts, such as interstate wars and civil wars [24], mostly in Africa [23]. However, since 2013, conflict-induced death toll has started rising (Figure 1.2) as a result of the deadly unrests in the eastern Mediterranean region following the revolutions, 'Arab uprising', government changes (Egypt, Libya, Tunisia, and Yemen), civil wars (Syria and Yemen), persistent civil disturbances (Afghanistan, Iraq, Palestine, and Somalia), the rise of Islamic State [12] and the South Sudan civil war.

Forced displacement has been rocketing in the recent years as well (Figure 1.2), highlighting the continued vulnerability. According to the United Nations High Commissioner for Refugees (UNHCR), the year 2015 registered a record-high forced displacement figure. The number of individuals uprooted from their homes because of violent conflicts and human rights violations reached 65.3 million worldwide; half of them (51%) were children under 18 years of age. As a result, in 2015, one in every 113 people in the world was either refugee, internally displaced, or asylum seeker [13]. Although developing countries are the main contributors to a large number of displaced populations in the world, they also host large share of them. Accordingly, more than 86% of the displaced people are hosted in developing countries [13], where the countries themselves are struggling with their own development and governance challenges.

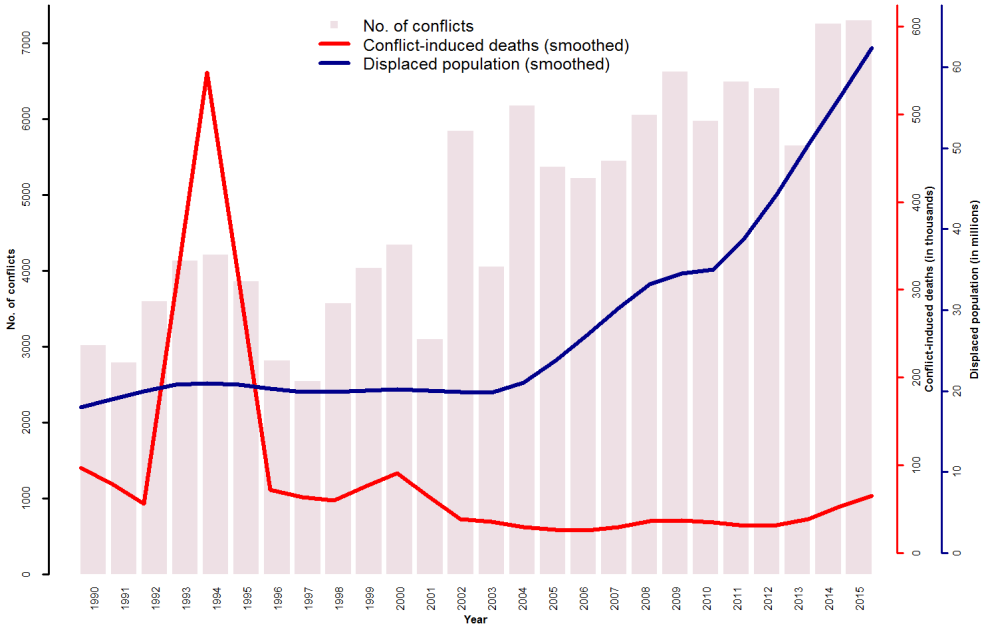

FIGURE 1.2: **Levels and trends of conflicts, conflict-induced deaths and forced displacement in the world, 1990–2015.** Conflict event data was obtained from the UCDP GED. The UCDP GED covers individual events of organized violence at global level. In the UCDP GED dataset, event is defined as "an incident where armed force was by an organized actor against another organized actor, or against civilians, resulting in at least 1 direct death at a specific location and a specific date" [32, 33]. Data on forced displacement was extracted from the UNHCR reports (http://popstats.unhcr.org/en/overview). Displaced people include refugees, asylum seekers, and internally displaced persons (IDPs). For better visibility of the trends, we smoothed the data using local regression methods.

1.3 The Cost of Humanitarian Emergencies: The Ethiopian Context

1.3.1 The human impact of droughts in Ethiopia

Owing to its diverse geo-climatic conditions, Ethiopia is vulnerable to a wide range of hazards, particularly droughts and floods. Consequently, the country has been experiencing recurrent food shortages across time and space, and has been portrayed as a drought-stricken country. The

most prominent drought was the 1984–85 famine, which attracted worldwide attention following media coverage, and it prompted unprecedented humanitarian interventions. The famine severly affected the over-cultivated and densely populated highlands in the north of the country, including Tigray, Wollo, northern Shoa, and Eritrea (the then Ethiopian territory). It was worsened by the ongoing civil war and engendered more than 9 million people ($\sim$23% of the total population) to suffer from severe food shortage, contributed to disease spread (especially measles and diarrhea-related diseases), and killed about a million people and hundreds of thousands of livestock [34–36]. Twenty years later, its long-term effects are still evident; those who experienced the shock as infants during the crisis become shorter in adulthood, less likely to have completed their primary schools, more likely to have experienced sickness, and will face about 5% income loss per year over their lifetime [37]. Furthermore, famines in the country contributed to the downfall of the previous regimes; the 1973–74 famine led to the removal of the Emperor regime, whereas the 1984–85 famine accelerated the collapse of the *Derg* regime [38].

Despite different efforts to mitigate the impact of droughts, ranging from policy formulation to grassroots levels of implementation, in recent years, drought frequency and its impact have been increasing in Ethiopia. Drought occurrence interval has shortened rapidly, occurring annually in some parts of the country. Apart from the crop growing highlands, intense droughts are apparent in the arid and semi-arid lowlands of Afar, Somali, and parts of Oromia and the Southern Nations, Nationalities and Peoples' (SNNP) regions [39]. This is driven mainly by the rapid population growth, land degradation, climate change, rainfall variability, and low crop and livestock productivity [34, 40, 41]. The trend of drought-affected population was peaked in the early 2000s, where more than 13 million people were affected. Thereafter, it declined sharply until it started increasing as of 2011 (Figure 1.3) following the 2010–11 droughts in Eastern Africa [21]. The drought effects are likely to continue increasing as a result of the heavy toll of El Niño weather events which started in late-2015 (Figure 1.3, [8]).

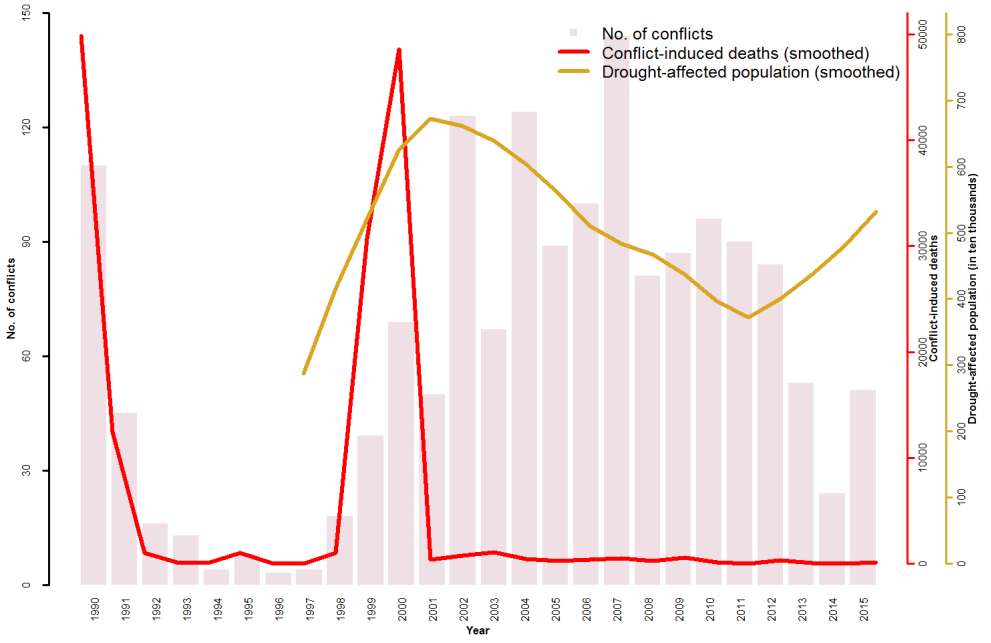

FIGURE 1.3: **Levels and trends of drought-affected population and conflict-induced deaths in Ethiopia, 1990–2015.** The conflict data was obtained from the UCDP GED [32, 33]. Data on drought-affected population was obtained from the EM-DAT (http://www.emdat.be/; [17]), Desinventar (http://www.desinventar.net/) and the Disaster Risk Management and Food Security Sector (DRMFSS) of Ethiopia (http://www.dppc.gov.et/). If two or more of the databases were reporting different number of affected population, the average was taken. For better visibility of the trends, we smoothed the data using local regression methods.

1.3.2 The human impact of conflicts in Ethiopia

For decades, Ethiopia has been marred by a string of intra- and inter-state violent conflicts and protests. During its 17-year in power (1974–1991), the military regime *Derg*, has killed an estimated 100,000 adversaries, including students and intellectuals, and additional thousands of civilians [42]. Internal clashes remain widely prevalent and are responsible for displacement and death of thousands of civilians. Examples include conflicts arising due to boundary making between regions (e.g., Oromia versus Somali, Oromia versus SNNP, and Afar versus Somali); intra-regional conflicts among different ethnic groups, such as conflicts between clans within Somali region (e.g., Ogaden versus Mejerti, and Darod versus Dir), conflicts among multi-ethnic SNNP

region (e.g., Surma versus Dizi, and Burji versus Koore) and in Gambella region (e.g., Anuak versus Dinka, and Nuer versus Anuak) [43, 44]. As of July 2015, for example, inter-communal and cross-border violent conflicts displaced more than 413,400 people within Ethiopia [45]. In addition to that, conflict on the border between Oromia and Somali regions has left around one million people displaced internally (nearly 700,000 in 2017 alone) [46].

In recent years, protests are becoming more frequent. A notable example is the wave of protests, which began in late-2015 in Oromia region sparked by the government plan to expand the capital, Addis Ababa, into the neighboring Oromia region. The protest then spread to Amhara and other regions of the country. The failure of the government to handle the grievances and the brutal response of security forces on protesters escalated the tension. The protest becomes violent and affected a large part of the country; lives were lost, security and stability threatened, public and private properties damaged, and finally provoked the declaration of a 10-month long state of emergency in October 2016 [47]. After a relative calmness, the anti-government protests and violence flared up again and forced the government to impose a state of emergency for the second time in February 2018. Moreover, disputes over elections sometimes go bad; for example, following the 2005 general election results, violent protests erupted and crackdowns by security forces led to the death of about 200 people and imprisonment of more than 30,000, including opposition leaders, opposition supporters and students [48, 49]. Overall, internal conflicts and protests are becoming more prevalent and claiming thousands of lives, displacing hundreds of thousands, destroying properties and deepening insecurity.

Conflicts between the government and armed insurgencies, including the Ogaden National Liberation Front (ONLF), the Oromo Liberation Front (OLF), the Islamic Court Union (ICU) from Somalia, and adversaries supported by the Eritrean government, are also frequent and deadly [43, 44, 48]. In 2007, for example, ONLF, the ICU ally, attacked a Chinese oil exploration site in Somali region and killed 74 civilians, including 9 Chinese. Somalia militias who are trained and

armed by Eritrea, Islamist militias, and foreign jihadist insurgents have been causing violence against civilians in Ethiopia [48]. In addition to that, the 1998–2000 war between Ethiopia and Eritrea, which was erupted over border disputes and economic issues, aggravated malnutrition, displaced over 10,000 people and claimed more than 100,000 lives, apart from its huge impact on development and social investments [42, 50].

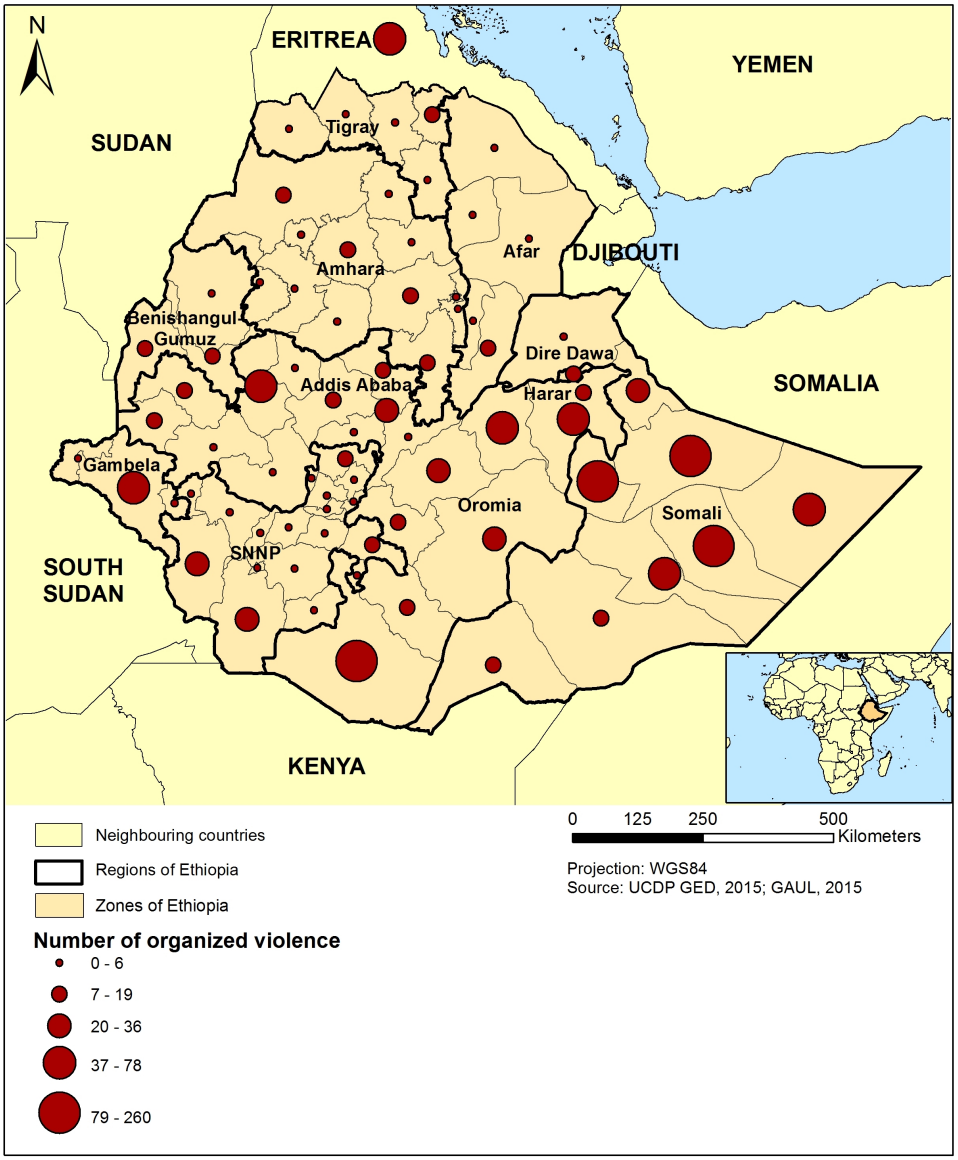

FIGURE 1.4: **Number of organized violence by regions and zones in Ethiopia, 1990–2015.** The conflict data was obtained from the UCDP GED. Organized violence is defined as a phenomena of lethal violence occurring at a given time and place [32, 33].

Overall, according to the UCDP data [32, 33], Ethiopia has experienced 1592 organized violence between 1990 and 2015. The peaks of conflict-induced deaths were during the early-1990s war to overthrow the *Derg* regime and the 1998–2000 Eritrea-Ethiopia war (Figure 1.3; Figure 1.4). Then after, conflict-induced deaths declined sharply and stabilized at the lower rate (Figure 1.3). Zones in Somali region experienced many organized violence as a result of persistent conflicts among the different clans and cross-border conflicts with neighboring regions and countries. Similarly, some zones in Gambella and Oromia regions had heightened conflicts over the period (Figure 1.4).

1.4 Conceptualizing the Causes of Malnutrition in Humanitarian Emergencies

The causes of malnutrition are interlinked in a complex and subtle way. Understanding this complex pathways is essential to improve nutritional status thereby reducing its short-term as well as intergenerational consequences. In the 1990s, the United Nations Children's Fund (UNICEF) developed a conceptual framework in order to understand the scale and depth of the problem and the pathways through which different factors affect the nutritional status of women and children [51]. Later, different researchers and agencies adopted the UNICEF framework to assess malnutrition causes in humanitarian settings (e.g., [52–54]). Accordingly, the causes of malnutrition are divided into three main groups: immediate, underlying and basic causes (Figure 1.5).

1.4.1 Immediate causes

The immediate causes of malnutrition have two dimensions: inadequate food intake and diseases (Figure 1.5), both operate at an individual level. Inadequate food intake, such as insufficient and infrequent food, poor diet diversity, and low-calorie- and nutrient-foods, contributes to malnutrition. In addition, common diseases in emergency settings, including measles, diarrhea, acute respiratory infections, malaria and intestinal worms, aggravate malnutrition through appetite loss, weakening nutrient absorption capacity of the body, altering the metabolic activity, and causing the body lose nutrients through

vomiting or diarrhea. Overall, malnutrition increases susceptibility to diseases and conversely diseases worsen malnutrition [51, 53, 55].

1.4.2 Underlying causes

The underlying causes of malnutrition, the main reasons for poor dietary intake and diseases, are numerous and usually interrelated. They operate at household and community levels and are classified into three main teams: insufficient access to food, poor health services and unhealthy environments, and inadequate maternal and child care practices (Figure 1.5).

Physical inaccessibility and socioeconomic difficulties to access adequate food together with inadequate food utilization put households in a state of food insecurity [57]. Food insecurity leads to a suboptimal food intake, hunger, and sometimes famine thereby impacting nutritional status and the overall physical and mental well-being. To ensure good nutrition, it is mandatory to address the food security dimensions: availability, accessibility, utilization and stability of food [9, 57]. Efficient use of agricultural knowledge and technologies, adequate agricultural inputs, improved livestock productivity, better policies and practices, employment opportunities, economic growth, education and training, and infrastructure developments are among the factors to enhance the food security dimensions [9]. Transitory and chronic food insecurity are widespread in parts of the rural Ethiopia [58, 59]. Recurrent droughts, land degradation, rapid population growth, fragmented land holdings, and limited off-farm employment opportunities are among the reasons cited for recurrent food shortage in the country [34, 40]. Sometimes, even under ideal weather conditions, seasonal hunger and malnutrition are apparent, showing that drivers are manifold and complex. Consequently, every year, a significant portion of Ethiopians are dependent on relief food assistance [36, 60]. On top of that, violent conflicts, when they occur, disrupt food stocks which induce food price inflation and force households to reduce meal frequencies or switch to cheaper, less desirable and poor nutritious foods [52]. To sum up, food insecurity at the household level directly affects individual's food intake and contributes to poor nutritional status.

Access to health services and a healthy environment contributes to optimum nutritional status. A healthy environment, including adequate water and sanitation, proper shelter and clothing, hygienic handling of food together with affordable and quality health services, are essential to good health [53, 56]. Shortage of health centers and medical staffs, poor supply of drugs and medical supplies, unaffordable user fees, poor health-seeking behavior, and insufficient attention to preventive healthcare and nutrition hinder access to appropriate and timely health services in developing countries [56]. Nonetheless, during humanitarian emergencies, it is challenging to deliver quality health services and healthy environment as crises often disrupt the routine health service provisions, induce shortage of medical supplies, force health care providers flee their posts, damage or destroy health infrastructures, deteriorate the health environment, destruct water and sanitation, and encourage the spread of infectious diseases [26, 52].

Even though adequate dietary intake and control of diseases are prerequisites to reduce malnutrition and mortality, they will not make significant impact without proper maternal and child care practices. Provision of care according to the cultural and societal context is important to meet the physical, mental, and social needs of children and mothers. Appropriate care for women, including adequate rest time, psychosocial support, hygiene practices, food preparation and storage practices, breastfeeding and child feeding practices, and appropriate health-related behaviors, are crucial for good nutrition and health [51, 53, 61]. Humanitarian emergencies compromise the care provision through disrupting the society, breaking-up the community, and weakening the social support structure; reducing the psychosocial care, time and resource allocated to the child as caregivers spend most of their time searching for income, water, and food; creating stress, fear, and anxiety among caregivers and children; disturbing food preparation practices and causing food contamination as a result of poor water supply and sanitation; inducing resource and material shortages; introducing untargeted distribution of relief food and milk products that affects safe and appropriate feeding practices [51–53, 61]. Furthermore, conflict increases violence against women in the form of rape or domestic violence [62]; this, in turn, has an intergenerational effect on

the victims through increasing the risk of premature and stillbirths, and malnutrition [63], among others.

Poverty and limited access to resources are interlinked to all the underlying determinants. For example, access to food becomes difficult as the families cannot produce or have money to buy any. Maternal and child care is affected as men often absent from home to search for jobs leaving the women to bring up children alone. Women often have less access to income, land and other resources which constraints their decision-making power in the household. It also contributes to lack of sympathy among families and leads to quarrels and child abuses. Healthcare utilization is jeopardized, especially when the healthcare fee is on an out-of-pocket basis [51, 56], as the case in Ethiopia.

1.4.3 Basic causes

The basic causes of malnutrition reflect a wide range of factors operating at the subnational, national and international levels; and they trigger the underlying causes. These include human and physical resource availability; social, economic and political context; and ideological factors (Figure 1.5). Inefficient use of technologies, excessive reliance on external economies or food imports, and unfair distribution of assets, such as land ownership, affects the underlying causes of malnutrition. Prevailing ideological factors, such as religion, culture and traditional beliefs, may also contribute to malnutrition through affecting health service utilization, food production and feeding habits; keeping women in subordinate position in the society; and legitimizing power imbalance within and among households. Moreover, the democratic level of a country; changes in political and policy dimensions, including price and subsidization policy or redistribution policies; the legal systems and the role, transparency and power levels of national institutions sometimes create tensions within and between countries which lead to civil disorder, war, and their brutal consequences [51, 56]. For these reasons, long-term and holistic development strategies are vital to address the basic causes.

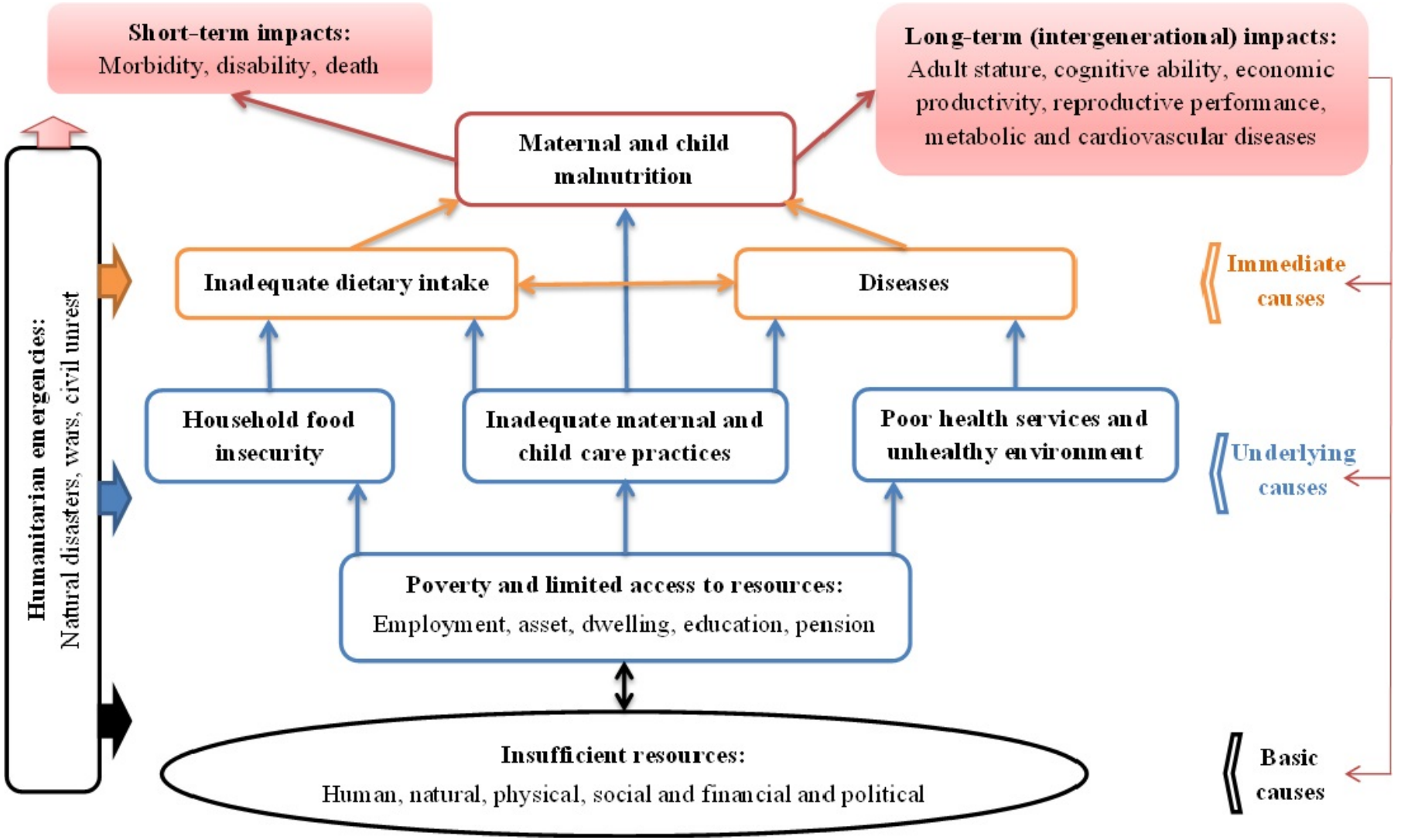

FIGURE 1.5: **Causes of malnutrition and its impacts, considering humanitarian emergencies.** Adapted from [51, 52, 54–56] and the authors.

As a recap, humanitarian crises, when they happen, destroy livelihoods and food crops, disturb food demand and supply, hamper maternal and child care practices, obstruct healthcare provision, contribute to micronutrient deficiencies, and increase the risk of morbidity and mortality. Furthermore, they trigger mass displacement and therefore overcrowding of people in an inadequate shelter, poor hygiene, and insufficient water supply encourages the spread of infectious diseases; this, in turn, alongside poor security and stress, creates public health crises. All these aggravate child and maternal malnutrition, and most importantly, the damage suffered in early life inevitably affect future generations (Figure 1.5).

1.5 Framework of Drought as a Risk Factor for Excess Morbidity and Mortality

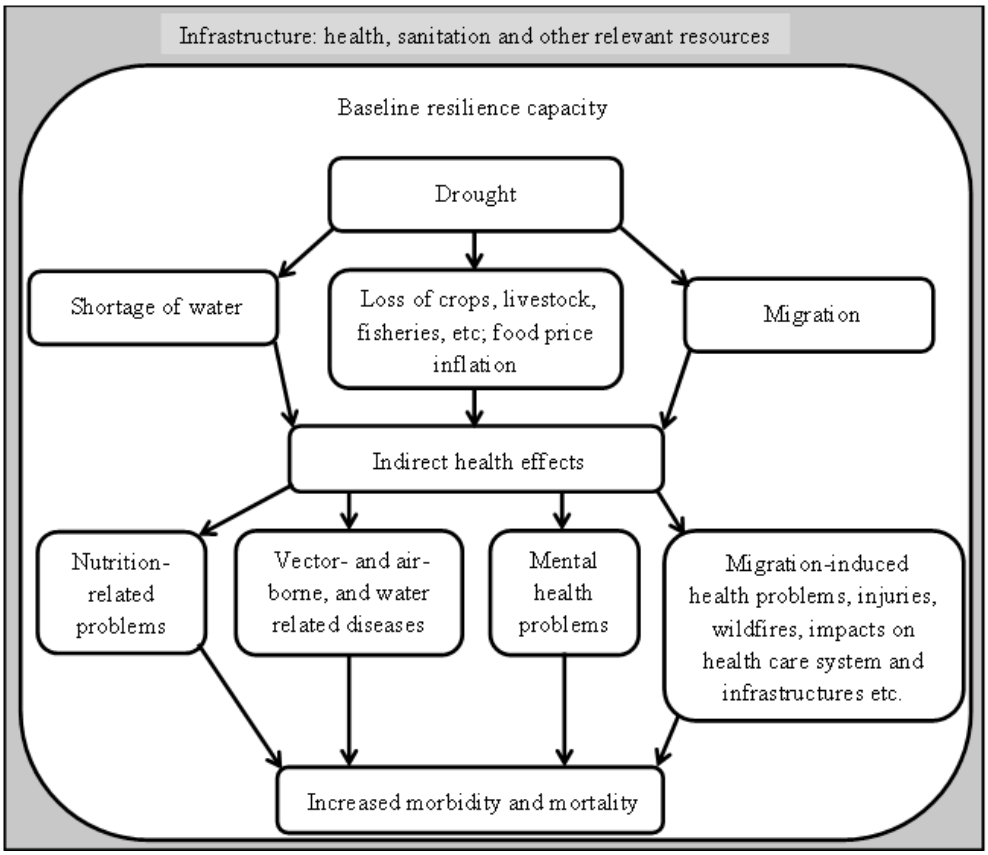

FIGURE 1.6: **The health impact of drought.** Adapted from [64, 66] and the authors.

The pathway through which drought increases morbidity and mortality is indirect and complex (Figure 1.6). Drought affects food and water security, reduces food consumption, diminishes dietary diversity, damages livelihood and leads to population displacement thereby contributing to poor health and elevated mortality. Its severity depends on the socioeconomic conditions, infrastructure development, stability and the general environment which directly influence the resilience capacity of the population [64–66].

1.6 Data for Effective Humanitarian Decision-Making: Challenges and Prospects

Reliable and timely epidemiological data are central to build a strong evidence-base for appropriate response and preparedness efforts during humanitarian emergencies. They are also pivotal for effective advocacy and for tracking accountability [15, 67]. However, the breakdown of the existing health information systems, mass population movements, and insecurity during humanitarian crises makes reliable data acquisition process extremely difficult [15, 68]. The public health surveillance systems (a continuous, systematic collection, analysis and interpretation of health-related data) which are often weak in many low-income countries [69] becomes nonfunctional during crises. For example, until recently, countries engaged in instability and war, including Ethiopia, had no functional and effective health surveillance systems to generate relevant public health data. Moreover, Civil Registration and Vital Statistics (CRVS) systems, an important source of data on vital events, such as births and deaths, are either nonexistent or incomplete (they register only selected events or are plagued with poor quality) in most low- and middle-income countries, especially in sub-Saharan Africa [70].

The national data sources, including the Demographic and Health Surveys (DHS), the Multiple Indicator Cluster Surveys (MICS) and the population censuses, often exclude crisis-affected populations due to inaccessibility. For example, the 2011 Ethiopian DHS [71] and the 2007 Ethiopian population and housing censuses [72] excluded some of the enumeration areas because of droughts and security concerns.

Nonetheless, national surveys are mainly conducted once in 5 years (e.g., DHS surveys) or 10 years (e.g., population censuses) meaning that they are either outdated or most often does not match the needs. As the evolution of humanitarian crises is dynamic and rapidly changing, timely information is crucial to guide effective response. In addition, lack of baseline information for comparing the health situation before and after the humanitarian crises hamper the credibility of assessment results in emergency settings [15].

To circumvent the challenges of data acquisition for humanitarian decision-making, operational data (typically small-scale or subnational surveys, these terms are used interchangeably throughout the thesis) conducted in crisis-affected areas by humanitarian agencies have proved to be a useful source of information [68, 73]. However, beyond their limited use for operational purposes at their respective agencies, these surveys are rarely used as an alternative to guide policies and programs at national or subnational levels. This is mainly because the surveys are either not made available to the general public or needs advanced and innovative methods of data analysis. Similarly, the existing national population-based household surveys, such as the DHS, could still provide important insights into identifying vulnerable population groups and hotspot areas (areas in emergency situations), but they are underused.

1.7 Aims of the Study

Ethiopia has been confronted with humanitarian emergencies, predominantly recurrent droughts and political instability. About 11% of the total population are exposed to droughts [39] and inter-communal and cross-border violent conflicts are widely prevalent [43–46]. These events trigger food shortages and diseases, and therefore contribute to malnutrition and mortality. Nonetheless, comprehensive analysis of the impact of humanitarian emergencies on nutrition and mortality are limited in Ethiopia. This is mainly due to either the lack of nationally representative data in crisis-affected populations or the inaccessibility and non-generalizability of subnational health surveys conducted in such populations. Consequently, humanitarian decisions and advocacies are

often based on anecdotal information or non-representative survey results with limited geographical coverage. Recognizing these data challenges, initiatives, such as the Complex Emergency Database (CE-DAT) at the Center for Research on the Epidemiology of Disasters (CRED), compiles small-scale operational health surveys from humanitarian organizations and make them available for researchers and policymakers. This study, therefore, uses data from the CE-DAT in combination with publicly available data of drought exposure, food insecurity and conflict events to provide evidence to support malnutrition and mortality reduction efforts in humanitarian settings.

Despite the internal political and development challenges and proneness to recurrent droughts, Ethiopia is the leading refugee-hosting country in Africa (hosted about 800,000 refugees in 2015). The majority of refugees are from Somalia, South Sudan, Eritrea and Sudan who are fleeing civil war, human rights' violations and droughts in their countries [13]. For example, Gambela region, a region bordering South Sudan, hosted more than 280,000 mainly South Sudanese refugees in 2015 [13] and the region itself had a population of about 410,000 in that year [74]. Similarly, more than 250,000 Somalia refugees were hosted largely in camps located in the Somali region of Ethiopia [13]. Sometimes conflict between the local population and refugees occur as the locals blame the refugees for land grabbing, cattle stealing and environmental degradation, and they also feel that they enjoy better access to food, water, healthcare and education through humanitarian assistance [75]. Cross-border raids are also apparent in some of these refugee hosting border zones; for example, in April 2016, South Sudanese raiders crossed Ethiopian border and attacked 13 villages in Gambela region, stole more than 2000 cattle, abducted 125 children and killed more than 208 civilians [76]. Due to the recurrent droughts in Eastern Africa, the pastoral nomadic people cross the borders to find fresh pastures for grazing; this sometimes causes violent conflicts with the rival groups. Furthermore, inter-ethnic clashes and border-related disputes are getting rampant and increasing the number of Internally Displaced Persons (IDPs) within Ethiopia [43–46]. Although a detailed

assessment of health issues in such situations is crucial to identify vulnerable groups and determinants of poor health, the public health impacts of living near the borders are not well assessed in Ethiopia and elsewhere in the region. Against this backdrop, this thesis makes a detailed analysis of nationally representative household survey data, the Ethiopian Demographic and Health Surveys (EDHS), to fill the evidence gap for appropriate interventions.

Overall, this research project aimed to maximize the decision-making potential of national and subnational health surveys in humanitarian settings through the application of meta-analysis and multilevel modeling in a Bayesian framework. The findings provide evidence on the burden of malnutrition and mortality, and help evaluate the impact of different resilience measures in improving public health in humanitarian situations in Ethiopia. Furthermore, it provides useful baseline information for tracking the progress of health-related SDGs in humanitarian settings, particularly SDG target 2.2 "*end all forms of malnutrition*" and SDG target 3.2 "*end preventable deaths of newborns and children under 5 years of age*" [14], since the dearth of reliable empirical evidence is cited as one of the possible impediments to effectively measure its progress [77, 78]. The results could also be used as a *prior* information (in a Bayesian term) for designing future nutrition and mortality surveys in crisis-affected populations.

Overall, this thesis has the following specific objectives:

1. **To quantify the burden of child undernutrition and investigate its association with droughts and conflicts in Ethiopia.** This objective is addressed in **Chapter 3** (Are droughts bigger drivers of child undernutrition than conflicts in Ethiopia? Testing the power of small-scale surveys). To achieve this objective, we extracted 231 small-scale operational surveys from the CEDAT repository and merged them spatially and temporally with drought exposure and conflict events data from publically available sources. Then we estimated the pooled prevalence of wasting among 6–59-month-old children in crisis-affected areas; and examined the association between drought, conflict and child undernutrition, adjusting for region and survey years. We used

random-effects meta-analysis and meta-regression in a Bayesian framework for data synthesis.

2. **To quantify the burden of child mortality and examine the drought-mortality link in Ethiopia.** We addressed this objective in **Chapter 4** (Droughts and child mortality in Ethiopia: Can small-scale surveys tell us more about the mitigation efforts?). For this objective, we extracted 88 small-scale operational surveys from CE-DAT and merged them across space and time with drought exposure and food security data from publically available sources; and conducted random-effects meta-analysis and meta-regression in a Bayesian framework. We then estimated the pooled Under-five Death Rate (U5DR) in crisis-affected areas; and investigated the drought-mortality link, adjusting for contextual factors (food insecurity, vaccination coverage and acute malnutrition).

3. **To estimate the burden of women's malnutrition and identify its risk factors in crisis-prone border zones in Ethiopia. Chapter 5** (Do border residents suffer more from malnutrition? Scrutinizing nationally representative large-scale survey data) extends the analysis to consider the nutritional status of women living in close proximity to international borders, where the communities are prone to cross-border conflicts, refugee-related crises and are poorly developed. To meet this objective, we analyzed data from the 2011 EDHS. We fitted multinomial multilevel models in a Bayesian framework.

Chapter 2 presents the country profile, details of the data sources, and the statistical methods used in the thesis. **Chapter 6** discusses the main findings and limitations of the study, and sets an agenda for future works to improve data-driven decision-making in humanitarian emergencies.

Chapter 2

Methodology in Context

In this chapter, we present the country profile and the methodology used in the study. We describe the socioeconomic, political and health profiles of Ethiopia. Then we provide an overview of the data and the statistical methods used in the study.

2.1 Study Setting: Ethiopia Country Profile

2.1.1 Geography, climate and population

Ethiopia is located in the eastern part of Africa, known as "the Horn of Africa". It is landlocked and shares borders with Eritrea, Sudan, South Sudan, Kenya, Somalia, and Djibouti. The country is divided into nine regional states (Tigray, Afar, Amhara, Oromia, Somali, Benishangul-Gumuz, SNNP, Gambella and Harari) and two chartered cities (the capital, Addis Ababa, and Dire Dawa). The topographic features of the country range from the highest peak of 4,550 meters (m) above sea level at Ras Dashen in the northern highlands to the lowest elevation of 110m below sea level at Danakil Depression in the northeastern lowlands. Broadly, three climatic zones can be distinguished based on the height above sea level: cool highlands "*Dega*" (higher than 2400m), temperate zones "*Weyna Dega*" (1500–2400m) and the hot lowlands "*Qola*" (less than 1500m) above sea level. The climatic conditions vary between average annual temperatures of 10°C to 16°C in the highlands to 20°C to 30°C in the lowlands. The average annual rainfall of the country is 848 millimeter (mm), ranging from about 2000mm in some highlands to less than 100mm in some lowlands. The rainfall in Ethiopia is erratic, leading to high risks of intra-seasonal dry spells and annual droughts.

With a population of more than 94.3 million in 2017 [74], Ethiopia is the second most populous country (after Nigeria) in Africa. It is one of the least urbanized countries in the world; less than 20% of the population live in urban areas. According to the 2007 population and housing census, more than 45% of the population were below 15 years of age (15% were below 5 years of age); childbearing women (15–49 years of age) constituted nearly half of the female population. The country is ethnically diverse and embraces a variety of people from more than 80 different ethnic groups. The Oromo and Amhara ethnic groups constitute the biggest share, about 35% and 27% of the country's total population, respectively. Regarding religious composition, about 44% follow Ethiopian Orthodox, 34% Islam, 19% Protestantism, and 3% Catholicism and traditional religions [79].

2.1.2 Political context

Ethiopia is Africa's oldest independent country. The country was ruled by successive emperors until the last emperor, Haile Sellasie, who was overthrown by a military coup in 1974. Following the coup, a totalitarian one-party socialist government, the military *Derg*, assumed power. Soon after its assumption, the *Derg* launched the so-called "Red Terror" to eliminate all its opponents, and confronted grievances of different groups through military forces. This led to a widespread resistance from different groups throughout the country, including the Tigray People's Liberation Front (TPLF), the Eritrean separatist movements, and the OLF. The groups engaged in an armed struggle, which led to a devastating civil war for the most part of the 17-year rule of the *Derg* regime. In addition to that, the regime fought Somalia in 1977–78 following the Somalia invasion over the disputed Ethiopian region of Ogaden.

In mid-1991, the *Derg* regime was overthrown by the Ethiopian Peoples' Revolutionary Democratic Front (EPRDF), a coalition formed in early 1989 by TPLF and the Ethiopian People's Democratic Movement. Then the EPRDF established the Transitional Government of Ethiopia (TGE) in 1991. The main coalition parties constituted the TGE include the TPLF, the OLF, and the ONLF. However, due to ideological differences among the major coalitions, arguments broke out and led to the withdrawal of OLF and ONLF from the coalition in 1993. Since then, most of the OLF and ONLF leaders fled into exile and guerrilla fighting continued against the EPRDF government (an alliance of four main parties: the TPLF, the Oromo People's Democratic Organization, the Amhara National Democratic Movement, and the Southern Ethiopian People's Democratic Movement) [42, 44]. In the same year, 1993, Eritrea gained independence from Ethiopia through a referendum, and Ethiopia became a landlocked country. In 1994, the country ratified its first constitution recognizing the right of 'nations and nationalities' to self-determination up to and including secession. The constitution created a federal government with nine ethnolinguistically-based member states: Tigray, Afar, Amhara, Oromia, Somali, Benishangul-Gumuz, SNNP, Gambella, and Harari.

After four years of TGE (1991–95), in mid-1995, the Federal Democratic Republic of Ethiopia (FDRE) was proclaimed after the first-ever multi-party election. The EPRDF and its allies won the election, despite most opposition parties chose to boycott the election. The second general election was held in 2000, although the country was at war with Eritrea, and major oppositions refusing participation. The EPRDF and its allies won again. The third general election, which was considered as the country's first genuine competitive election was undertaken in 2005. Large and peaceful political rallies from both opposition and ruling parties were carried out across the country. The campaign messages were broadcasted in state-owned media and private presses. The electoral process was closely observed by several international observer missions, including the African Union (AU), the European Union, the Carter Center, and the local observers. Voter turnout was high. The opposition parties made a major achievement; the main oppositions, the Coalition for Unity and Democracy (CUD) and the United Ethiopian Democratic Forces (UEDF), won several seats in the capital, Addis Ababa, and other urban centers. However, they disputed the final results and the national electoral board investigations, claiming that they won an overall victory. Some opposition leaders refused to take their seats in the parliament despite winning the election, which led to the imprisonment of more than 30,000 people, over 200 of them were opposition leaders [48, 49].

Following the 2005 unprecedented election challenges, the EPRDF put in place a series of new laws which limits the activities of opposition political parties, independent media, and civil societies. As a result, the following national elections in 2010 and 2015 were noncompetitive and totally dominated by the ruling party, where the EPRDF and its allies collected 99.6% and 100% of the parliament seats, respectively, in the two consecutive elections [48, 49].

2.1.3 Socioeconomic status

Ethiopia is one of the world's poorest countries. Nevertheless, over the last couple of decades, except during the 1998–2000 Eritrea-Ethiopia war and the 2003–04 catastrophic droughts, the country has shown substantial economic growth. Notably, between 2004 and 2016, the

Gross Domestic Product (GDP) grew, on average, over 10% and the GDP per capita grew, on average, 42 USD annually (Figure 2.1). The proportion of people living in extreme poverty has declined from 46% to 23% between 1995 and 2015 [80] and the MDG target of halving extreme poverty between 1990 and 2015 has been achieved [81].

Agriculture is the main economic base for the country with 80% of the workforce employed in this sector, generating 70% of export earnings (mainly from coffee export) and producing 42% of the GDP in 2014 alone [82]. However, the agricultural sector is characterized by smallholders (highly fragmented landholdings) and highly dependent on rainfall, which increases vulnerability to droughts and therefore contributes to higher economic volatility. For example, the 2003–04 droughts dragged the GDP growth below zero (Figure 2.1), and the 2015–16 El Niño induced-droughts exerted a heavy toll on the economy [8, 60].

FIGURE 2.1: **Levels and trends of socioeconomic indicators in Ethiopia, 1990–2015.** Data source: World Development Indicators 2017 [3].

Parallel to the economic growth, Ethiopia has shown astonishing progress in the education sector. Accordingly, the net primary enrolment rate has increased sharply from 19% in 1994 to 86% in 2014

(Figure 2.1); adult literacy rate (the proportion of persons aged 15 and above who can read and write) has also increased from 27% to 49% between 1994 and 2015 [80].

Even with the progressive socioeconomic growth, the country still ranked 174 out of 188 countries in the Human Development Index (HDI) in 2014 – an index composed of life expectancy, education, and Gross National Income. Similarly, it ranked 129 out of 155 countries in Gender Inequality Index – an index indicating gender-based inequality in reproductive health, empowerment, and economic activity. Overall, Ethiopia's HDI and GDP per capita are below the average of countries in the low human development group and sub-Saharan Africa [82].

2.1.4 Health status

As in many developing countries, the health system in Ethiopia is underdeveloped. The population has been bearing the burden of potentially preventable diseases. On top of that, the majority of the population lives in rural areas (over 80% of the country's population) where access to modern health services are limited. In the last two decades, however, several policies and programs have been developed and implemented to expand access to health services and improve health outcomes [83]. Subsequently, physical access and utilization of health care have improved substantially through the construction of healthcare facilities and training and deployment of health care providers. In addition, the total health expenditures per capita increased from only 4 USD in 1995 to 27 USD in 2014 [80].

Health outcomes have considerably improved. The U5MR fell from 166 deaths per 1000 live births in 2000 to 67 in 2016 (Figure 2.2), and hence the country achieved the MDG target of reducing child mortality by two-thirds ahead of the 2015 deadline [81]. Maternal health service coverage improved: between 2000 and 2016, antenatal care utilization and institutional deliveries have increased from 27% to 62%, and from 5% to 26%, respectively [84]. Maternal and child nutritional status has also shown improvements; in particular, child stunting dropped from 58% to 38% and women's undernutrition declined from 30% to

22%, both between 2000 and 2016 (Figure 2.2). Life expectancy has increased from 47 years in 1990 to 64 years in 2014 [80].

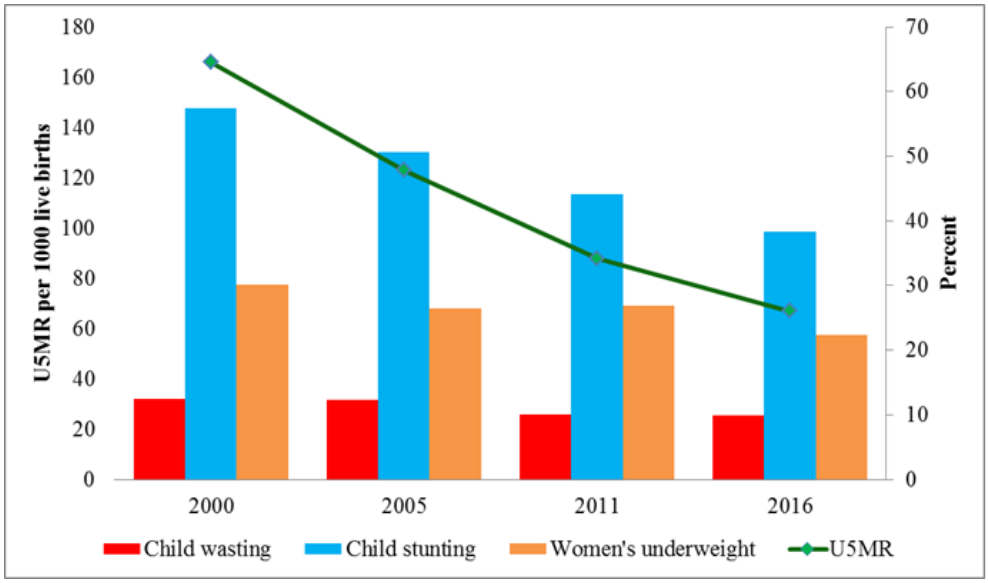

FIGURE 2.2: **Levels and trends of nutrition and mortality indicators in Ethiopia, 2000–2016.** Data source: The EDHS 2000, 2005 [85], 2011 [71] and 2016 [84].

Notwithstanding the progress in most health indicators, the prevalence of child wasting did not change much (Figure 2.2). Furthermore, the prevalence of both stunting and wasting indicates serious nutrition problems according to the WHO classification [86]. On top of that, there is a huge health inequality across regions, and between urban and rural areas. Between 2006 and 2015, for example, the U5MR of Affar region was more than twice that of Tigray region (125 deaths per 1000 live births versus 59); and higher in rural areas than in urban areas (83 deaths per 1000 live births versus 66) at national level. Similarly, in 2016, the prevalence of child stunting ranged from 24% in Gambela region to 46% in Amhara; and 40% in rural areas compared to 25% in urban areas, nationally. The prevalence of child wasting in Somali region was almost fourfold of that of SNNP region (23% versus 6%), but there was no substantial urban-rural difference (10% rural versus 9% urban) [84].

Despite the improvements, the country is still struggling with inadequate health systems. The health workforce and health infrastructure are far from reaching sufficient levels. Between 2007 and 2013, for

example, the physician, and nursing and midwifery ratios were 0.3 and 2.5 per 10,000 people, respectively, compared to the African regional average of 2.1 and 12.4; the hospital bed ratio in 2013 was one fourth of that of the African regional average (0.2 versus 0.8 per 100,000 people). In 2012, the GDP share of the health expenditure was lower than that of the African regional average (4.9% versus 5.6%) [87]; the total health expenditures per capita were also by far lower than the sub-Saharan African average (27 USD versus 131) in 2014 [80].

2.2 Overview of the Study Data

2.2.1 Nutrition and mortality

Nutrition

Nutrition is the intake of food according to the body's dietary needs. An adequate and balanced diet combined with regular physical activity is a cornerstone of good health. Malnutrition, either undernutrition or overnutrition, occurs when the dietary intake and absorption of nutrients is not balanced with the nutritional needs to sustain good health and development. Undernutrition is an outcome of insufficient nutrient intake or deficiencies of micronutrients. Overnutrition, on the other hand, is the result of overconsumption of food and nutrients, which develops into obesity, leading to chronic health problems, including cardiovascular diseases, hypertension, cancer, and diabetes. In this thesis, however, we consider only undernutrition because it is the common form of malnutrition in humanitarian crises and it provides insight into the severity of a crisis. Undernutrition occurs in four forms: chronic malnutrition, acute malnutrition, underweight, and micronutrient deficiencies. They can appear alone or in combination, but often overlap in a child or in a population.

Chronic malnutrition is characterized by low height compared to age (shortness) – referred to as stunting. Stunting is mostly irreversible and has a long-term effect on the individuals and the society at large. The effects include poor mental ability and learning capacity; reduced productive capacity at adulthood; increased risk of nutrition-related

chronic diseases, such as diabetes, hypertension, and obesity; and increased risk of complicated birth and adverse birth outcomes [55, 88, 89]. Stunting is a useful indicator to assess the long-term nutrition deficiencies and thus a preferable tool for long-term planning.

Acute malnutrition is characterized by either low weight compared to height (thinness) – referred as wasting (marasmus) – or nutrition oedema (kwashiorkor). Wasting is often the result of acute starvation or diseases and leads to quick and severe weight loss. It indicates the deficit in tissues and fat mass due to deficiencies of macronutrients (protein, fat, and carbohydrates) or micronutrients (essential vitamins and minerals, such as vitamin A, iron, iodine, and zinc). Nutrition oedema (a swelling caused by an excess accumulation of cellular fluids in the body tissue) is typically a sign of sudden lack of protein in the diet. Children who present oedema are at higher risk of death. The prevalence of acute malnutrition in children under-five years of age is a widely recognized indicator to assess the severity of humanitarian crises for the following main reasons [53]. First, it is a sensitive and objective indicator to assess the broader situation of crisis-affected population, including food security and public health. Second, it predicts morbidity and mortality better. Third, it is a fairly robust indicator to estimate the prevalence with known precision even in difficult situations. Hence, this thesis uses the prevalence of acute malnutrition (particularly wasting) as a proxy for nutritional status in humanitarian emergencies.

Underweight is characterized by low weight-for-age in children, and low weight-for-height in adults. It is the result of wasting, stunting, or both.

Nutritional status indicators are mainly obtained from anthropometric measurements of height, weight, mid-upper arm circumferences and sometimes skinfold thickness. Anthropometric indices based on height and weight – weight-for-height, height-for-age, and weight-for-age – are widely used tools to evaluate body size and composition. They are inexpensive, non-invasive and universally applicable and hence preferable for assessments of nutritional status at a population level [86].

Growth standards or growth references are required to compare growth patterns and to assess nutritional status based on the anthropometric indices. Accordingly, three growth standards have been widely used [90, 91]: the 1978 WHO/NCHS (National Center for Health Statistics) growth reference (for children up to age 10), the 1995 WHO growth reference (for children and adolescent up to age 19), and the 2006 WHO growth standard (for preschool children, under 6 years of age). The earlier versions of the growth references were developed based on data collected from children in the United States, where most of the children included were formula-fed, and thus cannot be considered as a good reference for many countries, including Ethiopia. With the aim to establish growth standards representative of different ethnicities or races, the 2006 WHO growth standard was developed based on breastfed and healthy infants and children recruited from cities of six countries (Brazil, Ghana, India, Norway, Oman, and the United States). We thus used indicators derived using the 2006 WHO growth standard (when it was readily available). Otherwise, we converted indicators reported based on the earlier growth references to the 2006 WHO standard using a conversion algorithm [92]. The indices are expressed relative to the reference or standard in any of the three methods: the standard deviation scores (z-scores), the percentiles, and the percentile of the median values [86, 91, 93].

The prevalence of child wasting at a population level is calculated as the proportion of the sampled children whose weight-for-height z-score (WHZ) is below the cut-offs (i.e., -2 z-score for Moderate Acute Malnutrition (MAM) or -3 z-score for Severe Acute Malnutrition (SAM)). The Global Acute Malnutrition (GAM) is then the sum of MAM and SAM. The WHO has set a classification benchmark on the severity of child wasting at the population level based on the prevalence of GAM. Accordingly, a GAM prevalence of less than 5% is acceptable, 5–9% is poor, 10–14% is serious, and greater than 15% is a sign of critical malnutrition in a population [86].

The Body Mass Index (BMI), weight (in kilograms) divided by height (in meter squared), is commonly used indicator to assess the nutritional status of adults. Individuals with low body weight relative to

height (low BMI) are considered underweight. Broadly, the WHO recommends the following BMI cut-offs: underweight ($<$ 18.50 kg/m^2), normal weight (18.50–24.99 kg/m^2), overweight ($\geq$ 25.00 kg/m^2) and obese ($\geq$ 30.00 kg/m^2). For public health significance, the WHO classifies the underweight prevalence in a population according to the following thresholds: $<$ 10%, 10–19%, 20–29%, and $\geq$ 30% as low, medium, high and very high prevalence, respectively [86].

Mortality

Humanitarian emergencies increase death toll either directly, or indirectly through adverse health outcomes. Mortality rates, excess death, and causes of death are among the key indicators used to evaluate the magnitude of humanitarian crises. They are crucial for planning and programming humanitarian response, including public health interventions and advocacies. Mortality indicators, including U5DR (the number of deaths occurring in a given population of under-five children during a specified time period) and Crude Death Rate (CDR; deaths among all age groups and due to all causes of death), are often calculated from retrospective mortality surveys in situations where death registrations are nonexistent or incomplete [94, 95].

Nutrition and mortality data in humanitarian emergencies

Nutritional status and mortality indicators are often collected through population-based household surveys. To generate timely and reliable data in a standardized way, the Standardized Monitoring and Assessment of Relief and Transitions (SMART) methodology was developed by a network of organizations and humanitarian practitioners. The accompanied SMART manual provides a step-by-step guide to conduct nutrition and mortality surveys in crisis-affected populations. The SMART methodology is supported by the Emergency Nutrition Assessment (ENA) software to facilitate the survey process and ensure standardization of results [96]. The majority of small-scale surveys used in this thesis are based on the SMART methodology. The following paragraphs briefly summarize the SMART survey methodology.

Generally, conducting a survey involves the following main components: selecting a representative sample of households or individuals, collecting data from the selected sample, and analyzing the data to infer about the population from which the sample was selected. Once the objective of a survey and the population group to be surveyed are defined, the sample size is decided. The required sample size is calculated using a formula which mainly contains the following parameters: the expected prevalence of malnutrition or death rates, the required precision, design effects (for cluster sampling) and the recall period for mortality (a predetermined period of time to which the mortality rate in a given population refers).

The next step is choosing appropriate sampling methods to select a representative sample from the population of interest. Different sampling methods exist: simple random sampling, systematic random sampling, cluster sampling and stratified sampling. Due to its feasibility and cost-effectiveness, two-stage cluster sampling is widely used and considered as a standard in humanitarian settings. In the first stage, the population is divided into smaller distinct geographical subdivisions, such as villages, districts, subdistricts or census blocks, whose population is known or can be estimated. A sample of these geographic units, Primary Sampling Units (PSUs), is selected in proportion to the size of the entire population (Probability Proportional to Size (PPS) sampling). The PPS ensures that all households have equal chances to be included in the sample. Then, a predetermined number of clusters within the selected PSUs (usually 30 or more) are selected. In the second stage, the required number of households or individuals within each PSUs are selected randomly using any of the following methods: simple or systematic random sampling, the Expanded Programme on Immunization (EPI) sampling methods, spatial sampling, or segmentation [96].

Once a representative sample is identified, the next task is collecting data using carefully designed questionnaires. Proper training should be given to the survey team before deployment in the field. The training encompasses several issues, including clarification of survey objectives, the roles and responsibilities of each team members, sampling methods emphasizing on the importance of random sampling, weight and height

measurements, assessing the presence of oedema, obtaining additional data (if needed), and administering mortality questionnaire. Before the rollout of the actual survey, it is important to undertake a full-scale pilot test in the field.

The final task is data analysis and writing the report. Indicators, including nutrition indicators (e.g., prevalence of wasting and stunting), immunization coverage indicators (e.g., Measles-containing Vaccine (MCV) coverage) and mortality indicators (e.g., U5DR and CDR), are calculated to represent the population from which the sample was selected. Then the report is prepared and disseminated to concerned stakeholders.

Ideally, prospective surveillance (an ongoing, systematic recording, analysis and interpretation of health data) based on CRVS (a continuous registration of vital events, such as births, deaths, and marriages) complemented by regular population censuses is considered as a gold standard for monitoring mortality. However, this system is absent or poorly developed in many developing countries, particularly in crisis-affected areas. This is mainly due to the poor health information systems, the costs to install the system, and feasibility issues in protracted crisis. Therefore, retrospective mortality surveys based on a representative sample of households are often used to monitor mortality in such situations. Mortality surveys collect information on the demographic events, such as births, deaths, arrivals, and departures, within a household over the recall period to calculate mortality rates. Nonetheless, retrospective mortality surveys have several shortcomings. For instance, mortality estimates reflect the past rather than the current mortality, delay in analysis and reporting limit the timely usefulness, the surveys are mainly based on smaller samples which may undermine the power to detect effects on further questions, and there are methodological challenges, such as lack of or incompleteness of sampling frames and selection biases [95]. Despite these weaknesses, retrospective mortality surveys are widely used for operational purposes by humanitarian agencies due to their cost-effectiveness and feasibility.

The CE-DAT (http://cedat.be/) at CRED (http://cred.be), Université catholique de Louvain (UCL) in Belgium, collects small-scale nutrition and mortality surveys from humanitarian and UN agencies, verifies the quality and ensures their completeness using the CE-DAT validation guidline (Appendix A), and compiles and makes them available for researchers and policymakers to support evidence-based humanitarian decision making [68, 73]. As of December 2013, the CE-DAT repository has recorded 3309 surveys from 51 countries for a period of 2000–13; a good half of them are from Sudan, DRC, Somalia and Ethiopia [68]. For this study, we extracted 237 small-scale surveys (consisting of a sample of 179,540 children) conducted in the third administrative (*woreda*) level of the rural Ethiopia between 2000 and 2014 (Figure 2.3). For the assessment of the burden of malnutrition among women living close to international borders in Ethiopia, we extracted data from the 2011 EDHS – which consists of 6334 women age 20–49 years (Figure 5.1).

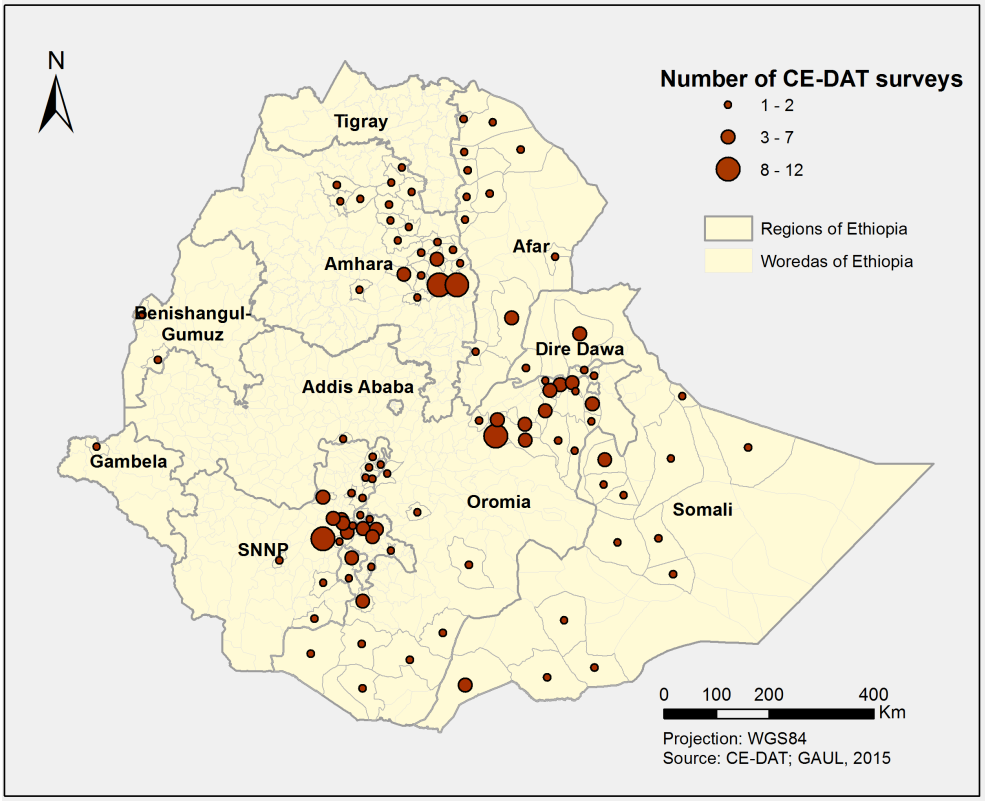

FIGURE 2.3: **The number of CE-DAT surveys (*n=237*) by *woredas* and regions of Ethiopia, 2000–2014.**

2.2.2 Drought exposure

Drought is a natural hazard which affects agriculture, water resource, and the natural ecosystem. It is primarily characterized by precipitation deficit. The timing, duration, distribution, and intensity of the deficit results in water shortage for the normal functioning of the natural ecosystem, particularly the human activities that depend on it [97]. This, in turn, leads to land degradation, economic loss, epidemics, and in the worst cases famine. It further contributes to widespread unemployment and poverty; exacerbates conflict and political unrest; and provoke mass displacement [98].

Droughts are broadly categorized into four types: meteorological, hydrological, agricultural, and socioeconomic droughts [99]. Meteorological drought is characterized by an abnormal precipitation deficit for a prolonged period, whereas hydrological drought refers to the deficiency of ground or surface water supply due to shortage of precipitation for a longer period. Agricultural drought, on the other hand, is characterized by soil moisture deficit during growing seasons due to meteorological or hydrological droughts and mainly affects rainfed agriculture (for a shorter duration). The socioeconomic drought occurs as a result of the imbalance of demand and supply of economic goods due to the effect of any of the droughts.

Characterizing droughts and assessing their impact is difficult for several reasons [65, 66, 99]. First, the onset and end of droughts are challenging to define, and this leads to different definitions based on regions, needs, understanding of the phenomenon, disciplines and its complex nature. Second, droughts develop slowly, last for longer periods, affect a wider geographical area and their effect accumulates over time. Third, the severity of drought depends on the underlying vulnerability of the population, such as infrastructure development and water utilization. Due to these reasons, there is no single universal indicator to adequately measure the intensity and severity of drought and its impacts. More than 100 indices have been developed so far; most of them are primarily based on precipitation deficit that results in water shortage for some activities or for some groups [100].

Among the indices, the Palmer's Drought Severity Index (PDSI) and the Standardized Precipitation Index (SPI) are widely used to quantify drought and monitor its development [99–101]. The PDSI uses precipitation and temperature data to estimate relative dryness. But, PSDI has several caveats, including its incomparability across regions and time periods, its limited applicability in regions with extreme climate (e.g., highly variable rainfall or runoff and mountainous areas), and its inability to identify a rapidly emerging drought events as it is based on a fixed time scale between 9- and 12-months [100, 101]. On the other hand, unlike PDSI, the SPI can track drought on multiple time scales (e.g., 1-, 3-, 6-, 42-month) and compares precipitation variations across different regions with different climates. Nevertheless, SPI is solely based on precipitation and ignores other potential factors that can influence drought, such as temperature, evapotranspiration and wind speed [100, 101].

Realizing the limitations of both PDSI and SPI, Vicente-Serrano and colleagues developed an improved drought index, the Standardized Precipitation and Evapotranspiration Index (SPEI, [101]), incorporating temperature data into SPI. The SPEI is therefore a comprehensive drought index which combines precipitation and temperature component (evapotranspiration) data in its calculation, and has a wider application. Its values usually lie between –2.5 and 2.5, where positive values indicate wetness and negative values indicate dryness. In this thesis, we used the SPEI to determine the duration and intensity of droughts. The SPEI data were downloaded from the Global Drought Monitor website, `http://sac.csic.es/spei/`, which provides real-time information about drought conditions at the global scale, with a 0.5° spatial resolution and a monthly time resolution for time-scales between 1 and 48 months.

2.2.3 Food security

Over the course of time, the term food security received several definitions, ranging from definitions considering only food availability to definitions considering several parameters. The widely accepted definition, which recognized the multidimensional nature of food security, was coined in the 1996 World Food Summit. According to this definition, food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life [102]. The food security definition basically has four dimensions: availability, accessibility, utilization, and stability. These dimensions are summarized below [9, 102]:

- **Food availability:** refers to the availability of food in sufficient quantity, appropriate quality, and adequate supply through domestic food production, commercial food imports or food aid.
- **Food accessibility:** refers to the ability of households or individuals to acquire the food necessary for a nutritious diet. It mainly depends on household resources, food prices, and the physical, social and policy environment.
- **Food utilization:** refers to sufficient socioeconomic and biological utilization of food. This encompasses the care and feeding practices; food preparation and storage; food preferences and intra-household food distribution; access to clean water, sanitation, and healthcare to reach the state of nutritional well-being while all physiological needs are met.
- **Food supply stability:** refers to the temporal dimension of food security. It is achieved when a population, household or individual has access to adequate food at all times. Stability of food supplies can be affected by sudden shocks, such as climate-related or economic crisis, and social or political instabilities.

Overall, to be considered food secured, food has to be available, households have to access it, be utilized properly, and foremost the whole system has to be stable over time and space. On the other hand,

food insecurity exists when people do not have adequate physical, social or economic access to food.

Food insecurity in humanitarian emergencies is assessed using different approaches. One of the widely accepted tools that provides information on the severity of food emergencies in a standardized way is the Integrated Food Security Phase Classification (IPC). The IPC classifies food security either at household or area level. The household approach uses the convergence of available information, including data on food security outcomes (e.g., household food consumption) and contributing factors (e.g., price level, crop production) to provide the estimated food-insecure population. The area approach, on the other hand, is based on convergence of the following three inputs: the highest severity of food insecurity faced by at least 20% of the area's population, the prevalence of acute malnutrition, and the death rates. Each of the scales has five phases to classify acute food insecurity: none or minimal, stressed, crisis, emergency, and famine or catastrophe (see the description in Figure 2.4). The IPC information is collected from different sources, including population censuses, food security surveys, DHSs, MICSs, health surveillance, and reports of governmental agencies, non-governmental organizations (NGOs) and UN agencies. The IPC approach is flexible and adaptable to different context, comparable over time and space, transparent and accountable, links analysis to action and, thus, provides comprehensive evidence for food security decision-making [57].

The Famine Early Warning Systems Network (FEWS NET; https://www.fews.net/) is one of the organizations providing current and projected food insecurity information at national and regional level. The FEWS NET adopted the IPC household-based classification of acute food insecurity reference table (Figure 2.4) to describe the severity of food crises. In this thesis, we used food insecurity information at *woreda* level, acquired from FEWS NET monthly reports.

Phases	Descriptions
Phases 1 No/ Minimal	Household group is able to meet essential food and non-food needs without engaging in atypical, unsustainable strategies to access food and income, including any reliance on humanitarian assistance.
Phases 2 Stressed	Even with any humanitarian assistance: ○ Household group has minimally adequate food consumption but is unable to afford some essential non-food expenditures without engaging in irreversible coping strategies.
Phases 3 Crisis	Even with any humanitarian assistance: ○ Household group has food consumption gaps with high or above usual acute malnutrition; or ○ Household group is marginally able to meet minimum food needs only with accelerated depletion of livelihood assets that will lead to food consumption gaps.
Phases 4 Emergency	Even with any humanitarian assistance: ○ Household group has large food consumption gaps resulting in very high acute malnutrition and excess mortality; or ○ Household group has extreme loss of livelihood assets that will lead to large food consumption gaps in the short term.
Phases 5 Famine/ Catastrophe	Even with any humanitarian assistance: ○ Household group has an extreme lack of food or other basic needs even with full employment of coping strategies. Starvation, death, and destitution are evident.

FIGURE 2.4: **Acute food insecurity phase descriptions, household-based classification [57].**

2.2.4 Conflict events

Several sources exist to provide information on violent conflicts and war. Administrative records of governments or other agencies, vital registration systems, routine surveillance and household surveys are widely used sources. Nonetheless, it is extremely difficult to obtain credible data on the burden of conflicts and war for different reasons [25]. First, the main data sources, such as media reports of eyewitnesses (combatant accounts) or official government reports, are prone to underreporting, selective reporting or exaggerations because of the political sensitivity of conflicts. Second, the various definitions of conflict itself complicate the assessment of the burden. Third, the lack of functional vital registration systems, weak surveillance, and incompleteness of national surveys as it often excludes conflict-affected areas, undermine the volume and quality of data. However, recognizing the need for reliable and timely data on the occurrence and impact

of conflicts, different initiatives have been involved in compiling and documenting data on conflict events. The following paragraphs briefly summarize the two conflict databases used in this thesis.

One of the initiatives is the Armed Conflict Location & Event Data Project (ACLED; http://www.acleddata.com/). ACLED is a publically available database of political violence (the use of forces by a group with a political purpose or motivation). It collects data on the type of violence, groups involved, dates and locations, reported fatalities and contextual notes of political violence and protests in developing countries. The ACLED data is geo-referenced and disaggregated by types of violence (battles, violence against civilians, remote violence, rioting, non-violent demonstration and non-violent activities) and actors (governments, rebels, militias, ethnic groups, political organizations, and civilians). It provides useful information to understand conflict dynamics and patterns as well as to identify conflict actors [103].

ACLED gathers information from a variety of sources, including civil societies (e.g., NGOs and humanitarian agencies), governmental or intergovernmental organizations (e.g., national governments, AU and UN), media (e.g., newspapers, magazines or television), research journals and specialist publications. It provides information in different scales, ranging from international to local levels. The use of diverse sources and different scales in ACLED is its strength in minimizing biases, such as reporting bias, geographical bias and selective reporting [103].

The ACLED data are coded by qualified and experienced professionals to ensure accuracy and ease usability. Each week individual coders collect data from the sources mentioned above. Then the data are reviewed by three code reviewers. The first reviewer aggregates and revises the data, the second reviewer investigates and crosschecks, and the third reviewer inspects the details and event notes (a brief note attached to each conflict event to provide additional details about the event). The real-time conflict data are reviewed in weekly bases and then the overall data cleaning and management is carried out in annual bases leading to an annually-released dataset publication. Inconsistent

and missing details are updated whenever new and credible information is available. The ACLED data is available for the entire African continent in their website, http://www.acleddata.com/.

The other initiative is the UCDP, http://www.ucdp.uu.se/, which records armed conflicts with the aim to help conflict resolution efforts through a better understanding of the origin and dynamics of conflicts. The UCDP defines armed conflict as a contested incompatibility that concerns governments or territories where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths in a calendar year. The UCDP classifies conflicts into 3 main groups: $i)$ interstate armed conflict, occurs between two or more states; $ii)$ internationalized internal armed conflict, occurs between the government of a state and internal opposition groups with intervention from other states; $iii)$ internal armed conflict, occurs between the government of a state and internal opposition groups [104].

The UCDP data collection exercise is carried out in four stages. In the first stage, data related to organized violence is collected through the Factiva database (a business information and research tool with global coverage and contains more than 30,000 different newswires (e.g., Reuters, AFP and Xinhua), newspapers and other sources). The collected information is then codded according to the UCDP's criteria. In the second stage, other materials which could possibly contain information are collected. These include newly published books and case studies, journals, NGO publications and online databases. Then it is coded in the same way as in the first stage. In the third stage, unclear information is checked by contacting a network of regional experts. In the fourth stage, the UCDP's project managers and program's director examine and validate the compiled data to be uploaded in the system. The UCDP armed conflict database publishes data on the incidence, duration, location, actors involved and number of deaths. The data can be downloaded from the UCDP website, http://www.ucdp.uu.se/.

2.3 Overview of Data Analysis

2.3.1 Bayesian approach

The discipline of statistics has two schools of thought: the classical (frequentist) approach and the Bayesian approach. The classical approach considers probability as a long-term relative frequency and hence applicable for repeatable events only (in principle). It is often based on large sample approximation by assuming asymptotic normality. The statistical methods based on the classical approach are heavily dependent on testing the null hypothesis. The unknown parameters in the classical approach are fixed quantities. A Bayesian approach, on the other hand, applies to any event about which we are uncertain. The unknown quantities (i.e., unknown parameters and data before observation) are considered as random and have a probability distribution. In a Bayesian approach, unknown quantities are assigned a *prior distribution*, and the latter is updated using observed data to give *posterior distributions*; which makes the Bayesian approach a method of learning from evidence as it accumulates [105, 106].

The benefits of Bayesian methods include [105–108]:

- It provides more information to improve decision-making. The Bayesian approach incorporates additional information into the statistical analysis in the form of *prior* probability distributions to provide flexible modelling of evidence from diverse sources.
- Sample size reduction. The use of *prior* information in the Bayesian approach could reduce large sample requirements.
- It provides more intuitive and meaningful inference. It gives exact analysis, unlike the classical approach which mainly produces approximate analysis.
- Missing data can easily be handled in a Bayesian approach.

To summarize, a Bayesian method combines prior information about the parameter *(prior probability)* with the observed data (*likelihood function*) to obtain a revised probability associated with the parameter *(posterior probability)* and makes inference from this combined information. We used Bayesian approaches throughout this thesis. The

following sections summarize the steps to undertake a Bayesian analysis [107–109].

1. Formulate a probability model for the data
   Suppose that $x = (x_1, ..., x_n)$ are the n data values to be observed and θ denotes the vector of unknown parameters. Further, assume that the observations are independent. Then, the probability distribution of the data if the parameters were known is given by $p(x_i/\theta)$.

2. Prior distribution
   Learning from the past through incorporating information from previous studies into the current studies would improve statistical inference [106]. In a Bayesian approach, before the data are obtained and the analysis started, probabilities are assigned to all the possible values of the unknown population parameters of interest. These probabilities constitute *prior distributions* for those parameters; and the variance of this distributions (often expressed as precision – the inverse of the variance) reflects the level of uncertainty about the values of the population parameters. We can broadly classify *prior* knowledge into two:

   – Informative (genuine) *priors*. They are used when there is considerable prior information about the values of the parameters of interest and their accuracy. They can be obtained either from elicitation of expert opinions (formal or informal discussions with experts, gathering information through questionnaires and computerized elicitation) or from previous similar studies ("today's *prior distribution* is yesterday's *posterior distribution*" [110]).

   – Noninformative (vague or diffuse) *priors*. They are widely used when there is little or no previous information about the parameters of interest. They represent ignorance about the model parameters and avoid the criticism of subjectivity by acting as if the *prior* information does not exist. They usually take the form of uniform distributions over the range of interest and have a negligible impact on the *posterior distribution*. If the data is large enough, the *prior* information

matters little or not at all and, thus, noninformative *priors* can be used.

For the unknown parameter θ under consideration, the initial knowledge prior to data collection can be represented by *a prior distribution*, $p(\theta)$.

3. Posterior distribution
   The *posterior distribution* provides updated information by balancing the prior knowledge with the observed data. To obtain the *posterior distribution*, $p(\theta/x)$, we follow the following procedures: construct the likelihood function based on the observed data and the probability model formulated in step 1, and then combine the likelihood with *prior distribution* obtained in step 2.

   The likelihood is the joint probability distribution function of the data (fixed quantity), as a function of the parameter. For the independently selected data values $x = (x_1, ..., x_n)$, the likelihood function is given by

$$L(\theta/x) = p(x_1, ..., x_n/\theta) = \prod_{i=1}^{n} p(x_i/\theta). \tag{2.1}$$

   Then, the *posterior distribution*, $p(\theta/x)$, is obtained by applying the Bayes' theorem as follows:

$$p(\theta/x) = \frac{p(\theta)p(\theta/x)}{\int p(\theta)p(x/\theta)d\theta} = \frac{p(\theta)L(\theta/x)}{p(x)} \propto p(\theta)L(\theta/x). \tag{2.2}$$

   To summarize, the *posterior distribution* is proportional to the *prior distribution* and the likelihood function.

   To find the implicit form of the *posterior distribution*, the proportionality constant, $p(x)$, which does not depend on θ and required to make $p(\theta/x)$ integrate to one, needs to be calculated. This process involves solving high dimensional integrations, which is the challenging part of the Bayesian approach. Because of this difficulty, the Bayesian statistics had limited practical applications

until the last two decades. With the advancement of fast and powerful computing machines and the emergence of Markov Chain Monte Carlo (MCMC) methods, the practical application of Bayesian statistics has become much easier [105].

The MCMC methods produce simulated draws of samples from the *posterior distribution*, easing the challenges of analytically solving the parameter estimates. Once the *posterior distribution* is constructed, the Bayesian inferences can be made by solving a large sample drawn from the distribution using MCMC methods. Both point and interval estimates (credible intervals) of the parameters, predictions about future data, and probabilistic evaluation of hypotheses can be computed from the *posterior distribution*.

Despite its benefits, the Bayesian approach has limitations [106–108, 111]. First, the use of subjective *prior* information is the source of controversy in Bayesian methods. This issue is even more important in emergency response, where malnutrition and mortality estimates, for instance, can be manipulated for political reasons or other interests of different groups. The subjectivity can be minimized by either choosing *prior* information based on justifiable evidence and reasoning so that it could reflect the real nature of the data or using non-informative *priors* to reflect ignorance of prior information. Given the scarcity credible evidence in the area, we have used noninformative *priors* in this study. Moreover, as our analysis is based on large datasets, the impact of *prior* information is negligible, and thus our findings could be used as a *prior* for future studies. Second, different choice of *prior* information can produce varying *posterior* results. Therefore, conducting sensitivity analysis is vital to assess the robustness of the results with the choice of different priors and any other assumptions made. Third, Bayesian methods are computationally complex and thus need specific statistical expertise.

2.3.2 Meta-analysis

We used meta-analysis in **Chapter 3** and **Chapter 4**. As science is a cumulative process, one can find a wealth of studies addressing the same research question [112]. Meta-analysis is a method to summarize, integrate, and interpret results of conceptually comparable and methodologically similar quantitative studies in an attempt to develop a single synthesis of the results, a so-called "pooled estimate". Some of the reasons to use meta-analysis for evidence synthesis include [113, 114]: (1) meta-analysis increases statistical power compared to individual studies and therefore answer questions (detect effects) that single studies cannot or are not designed to address; (2) it improves precision as it is based on more information; and (3) it helps resolve controversies by combining information from conflicting results.

Meta-analysis is usually a two-stage process [113, 114]. In the first stage, a summary effect is calculated for each study (e.g., odds ratios, relative risks, proportions, mean differences and correlation coefficients). In the second stage, a summary (pooled) effect estimate is calculated based on a weighted average of individual studies. Although meta-analysis aggregates information from conceptually comparable and methodologically similar quantitative studies, the studies may or may not estimate exactly the same effects. On this basis, two meta-analysis models exist; fixed-effect and random-effects meta-analysis.

Fixed-effect meta-analysis

A fixed-effect meta-analysis assumes that each study estimates exactly the same effect and hence a single parameter value (true effect) is common to all studies. Any differences observed in the effect size estimates are assumed to be due to sampling error. Assume n independent studies, each study $i(i = 1, ...n)$ estimating a corresponding true effect size. All the studies are assumed to share a common true average (unknown) effect (μ). The observed effect y_i in the i^{th} study is given by:

$$\begin{aligned} y_i &= \mu_i + \varepsilon_i \\ \mu_1 = \mu_2 = ... = \mu_n &= \mu \end{aligned} \tag{2.3}$$

where ε_i is the sampling error (within-study error) and follows a normal distribution with mean 0 and within-study variance δ^2_{yi} ($\varepsilon_i \sim N(0, \delta^2_{yi})$).

To obtain precise estimate of the population effect (μ), weighted mean is computed with each study assigned a weight which is the inverse of its variance – $w_i = \frac{1}{\delta^2_{yi}}$.

The weighted mean $(\hat{\mu})$ is then computed as:

$$\hat{\mu} = \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i}.$$

The variance of the summary effect is estimated as:

$$\delta_{\hat{\mu}^2} = \left(\sum_{i=1}^{n} \frac{1}{\delta^2_{yi}} \right)^{-1}.$$

However, the assumption of homogeneous effect sizes in the fixed-effect meta-analysis is difficult to achieve, except in the case where flawless studies estimate the same physical constant. In biomedical and social science studies, it is implausible to assume homogeneity [115]. Inevitably, the studies brought together differ in numerous factors, such as participants' characteristics (e.g., age, education, lifestyle and residence), the exposure or interventions under investigation (e.g., exposed to droughts, conflicts and educational intervention), outcomes measured, and study design implemented. These differences introduce variability (heterogeneity) among the true effects.

Heterogeneity

Heterogeneity is any kind of variability among studies compiled in a meta-analysis. Identifying heterogeneity, quantifying its extent and addressing them is a crucial part of any meta-analysis [116, 117]. The commonly used statistic to test or identify heterogeneity is the Cochran's heterogeneity statistic – Cochran's χ^2 or Q–test. The Q–statistic is expressed as: $Q = \sum w_i(y_i - \hat{\mu})^2$, which follows a χ^2 distribution with $n - 1$ degrees of freedom (df). Different methods have been developed to quantify heterogeneity across studies [113, 117]; notably, τ^2 (between-study variance) and I^2 (the percentage of total variation

across studies that is due to heterogeneity rather than chance).

The τ^2 is estimated using the method of moments as:

$$\hat{\tau}^2 = \frac{Q - df}{\sum w_i - \frac{\sum w_i^2}{\sum w_i}}.$$

If $\hat{\tau^2} = 0$, which implies homogeneity across the true effects, and the model reduces to fixed-effect model.

The I^2 is calculated as:

$$I^2 = \left(\frac{Q - df}{Q}\right) \times 100\%.$$

The value of I^2 ranges from 0–100%; heterogeneity increases as I^2 increase [116, 117].

Random-effects meta-analysis

One approach to account for heterogeneity is fitting a random-effects meta-analysis, where the effect sizes are assumed to differ from study to study. Thus, the true effects in each study ($\theta's$) are assumed to be a random sample from a distribution of effects. The random-effects model for the observed effect y_i in the i^{th} study is thus given by:

$$\begin{aligned} y_i &= \theta_i + \varepsilon_i \\ \theta_i &= \mu + u_i \end{aligned} \tag{2.4}$$

where u_i is the between-study error, assumed to be normal with mean 0 and between-study variance τ^2 ($u_i \sim N(0, \tau^2)$); and $\varepsilon_i \sim N(0, \delta_{yi}^2)$. The $\theta_i's$ are assumed to be normal with μ (the overall average) and τ^2 ($\theta_i \sim N(\mu, \tau^2)$).

To obtain an estimate for μ, weighted mean is computed. The study variance used to calculate the weight is composed of δ_{yi}^2 and τ^2, and the weight assigned to each study is $w_i^* = \frac{1}{\delta_{yi}^2 + \tau^2}$.

The weighted mean ($\hat{\mu}^*$) is then computed as:

$$\hat{\mu}^* = \frac{\sum_{i=1}^{n} {w_i}^* y_i}{\sum_{i=1}^{n} {w_i}^*}.$$

The variance of the summary effect is estimated as:

$$\delta^*_{\hat{\mu}^2} = \left(\sum_{i=1}^{n} \frac{1}{\delta^2_{yi} + \tau^2} \right)^{-1}.$$

Subgroup meta-analysis and meta-regression

In order to explore the observed heterogeneity (reasons why results may differ systematically), one can conduct subgroup meta-analysis or meta-regression by including study-level covariates (moderators) in the model. Subgroup meta-analysis is mainly conducted as an exploratory analysis and it facilitates comparison among categorical moderators, such as a subset of participants (e.g., literate or illiterate, male or female) and a subset of studies (e.g., geographical classifications, study quality). Meta-regression is an extension of subgroup meta-analysis; it accounts for confounders and allows the investigation of both continuous and categorical moderators simultaneously [111, 113, 118]. The random-effects meta-regression (mixed-effects meta-regression) is given by:

$$\begin{aligned} y_i &= \theta_i + \varepsilon_i \\ \theta_i &= \beta_0 + \beta_1 x_{i1} + ... + \beta_n x_{in} + u_i \end{aligned} \tag{2.5}$$

where x_{ij} denotes the j^{th} moderator variable for the i^{th} study; $\beta_i' s$ are regression coefficients; and $u_i \sim N(0, \tau^2_*)$ (here τ^2_* denotes residual heterogeneity, variability among the true effects that is not accounted for by the moderators included in the model), and $\varepsilon_i \sim N(0, \delta^2_{yi})$.

Despite its strength in suggesting reasons for the observed heterogeneity, this type of analysis is prone to aggregation bias (bias resulting from data aggregation) as the summary data of the participant's characteristics may not directly reflect the individual participant's characteristics. To circumvent this problem, the use of individual participant's data, if available, is advocated [111, 118]. However, due to difficulties

of obtaining individual participant's data from humanitarian organizations, this study is solely based on summary data.

Biases in meta-analysis

In a meta-analysis, biases can be introduced in several ways. The most common biases are related to publication, study location, and the inclusion criteria [119]. Publication bias could occur as a result of either some of the studies not being published or published studies report only selected results. Positive findings are more likely to be published and thus included in a meta-analysis than null findings, this leads to publication bias. Similarly, selective reporting of results of a study could also lead to publication bias [119, 120]. Biases in the location of the studies include a language bias, citation bias, and multiple publication biases. Sometimes authors tend to publish positive findings in English-language international journals and negative findings in local journals; this, in turn, increases the chance of English language journals to appear more in a meta-analysis. Citation bias is apparent when reference lists of other studies or reviews are being used to locate studies. Further, journals in which the studies are published influence the choice of studies to be included in a meta-analysis. Some studies may be published more than once or are presented in different ways, which leads to duplication of results thereby overestimating the effect sizes. Bias could also be introduced while setting the inclusion criteria; for example, manipulating the inclusion criteria to include only studies with positive findings [119].

The small-scale surveys compiled in the CE-DAT are gathered from several humanitarian organizations. CE-DAT is the most complete and unique database of nutrition and mortality surveys from humanitarian emergencies. Particularly, the majority of surveys conducted in Ethiopia are reported and available in CE-DAT, given the strong collaboration of CRED with humanitarian agencies operating in the country [68]. Further, the majority of the surveys follow a standard survey methodology, SMART, and all of them are reported in the English language. Predefined and clear inclusion criteria were used to select surveys included in the meta-analysis. It is inevitable to have biases in a meta-analysis, but

we believe that the surveys included in our meta-analysis have minimal bias due to the aforementioned reasons.

Bayesian meta-analysis

The application of a Bayesian approach for meta-analysis in healthcare research has been gaining popularity in recent times. Sutton and Abrams summarized the benefits of a Bayesian approach to meta-analysis over the classical approach as follows: evidence from a variety of sources can be included in the model; predictive statements can easily be made based on the current state of knowledge; similar units of analysis borrow strength from other units to estimate effects; probability statements can be made directly to the variable of interest; and all parameter uncertainties are taken into account in the analysis. Furthermore, the use of prior information can reduce the chance of confounding, improve efficiency, limit bias in estimating parameters, and provide an acceptable basis for evidence synthesis [111].

The random-effects meta-analysis can be modeled in a Bayesian framework by assigning *prior distributions* for the unknown parameters. The observed effect y_i in the i^{th} study is given by

$$\begin{aligned} y_i &= \theta_i + \varepsilon_i \\ \theta_i &= \mu + u_i \end{aligned} \tag{2.6}$$

where $\theta_i's$ are the true effects, $\theta_i \sim N(0, \tau^2)$ (μ is the overall average and τ^2 is the between-study variance). As we have aggregated large number of studies in our meta-analysis, the choice of the prior information may not have a substantial impact on the posterior inference. Thus, the posterior results are predominantly based on the data. The noninformative *priors* used are: normal *prior* with large variance for the overall average parameter, $\mu \sim N(0, 10^6)$; and inverse-gamma *prior* for the precision parameter, $\tau^2 \sim inverse - gamma(10^{-3}, 10^{-3})$.

A Bayesian random-effects meta-analysis can be extended to a Bayesian meta-regression or mixed-effects regression as

$$\begin{aligned} y_i &= \theta_i + \varepsilon_i \\ \theta_i &= \beta_0 + \beta_1 x_{i1} + ... + \beta_n x_{in} + u_i \end{aligned} \tag{2.7}$$

where the regression coefficients $\beta_i's$ assigned noninformative normal *priors* with large variance, $\beta_i \sim N(0, 10^6)$, and the precision parameter τ^2 assigned $\tau^2 \sim inverse - gamma(10^{-3}, 10^{-3})$.

2.3.3 Multilevel or hierarchical models

We used multilevel analysis in **Chapter 5**. Multilevel analysis (hierarchical modeling) provides objective basis to investigate the effects of micro-level of individuals and macro-level of groups simultaneously, with the notion that individuals may be influenced by their groups or contexts. It has been widely used in the fields of education, sociology, demography and recently in public health. The community-, ecological-, or group-level determinants of health and the interaction of individuals within their community or groups are relevant to understand the distribution of health outcomes [121]. Moreover, data gathered from social, medical and biological sciences mainly lend itself to hierarchical structures. For example, in a household surveys, individuals are nested within their households; the households, in turn, are nested within their communities; and the communities, in turn, are nested within their next higher groupings, etc. In general, units at one level are grouped or nested within units at the next higher level [122].

Ignoring the hierarchical or group level structure in the dataset weakens the validity of the statistical inference. Often, individuals within a cluster share similar characteristics or exposed to the same external factors. Thus, the individual's outcomes within a group (cluster) tend to be more similar than outcomes taken from other groups (i.e., correlated). This violates the assumption of independence of observations; results in incorrect standard error estimates (standard errors are underestimated) and eventually incorrect inference, often leading to statistically significant results. Therefore, multilevel analysis,

unlike the classical single-level modeling, acknowledges the hierarchical structure and allows the simultaneous investigation of group- and individual-level effects by taking into account the correlation of observations within groups. Moreover, it recognizes the interdependence of groups or contexts themselves and examines both inter-individual and inter-group variations as well as the contributions of individual- and group-level variables to these variations [121–123].

The statistical modeling

Multilevel models are generalizations of regression methods. In this thesis (**Chapter 5**), a multilevel model involving two levels (e.g., individual women (level-1) nested within their communities or clusters (level-2)) was implemented. A two-level model can be given in a two-stage system of equations: individual- and group-level equations. The individual-level equation models the individual variations in each group, whereas the group-level equation models the variation across the groups. We fitted a multilevel model for multinomial (proportion) data, specifically two-level multinomial logistic regression models.

Suppose that a dataset consists of J ($j = 1, ..., J$) independent clusters (level-2 units) and the j^{th} cluster consists of n_j individuals (level-1 units). Let y_{ij} denotes the i^{th} individual ($i = 1, ..., n_j$) response in the j^{th} cluster, where this response is from one of the r ($r = 1, ..., R$) distinct categories, and let the category $r = 1$ is taken as a reference category. Further, x'_{ij} denotes a column vector of p covariates for the i^{th} individual in the j^{th} cluster. The random intercept multinomial logistic model is given by:

$$log\left(\frac{\pi_{ij}^{(r)}}{\pi_{ij}^{(1)}}\right) = \beta_0^{(r)} + \beta^{(r)} x'_{ij} + u_j^{(r)}, \qquad r = 2, ..., R \tag{2.8}$$

where $\pi_{ij}^{(r)} = P(y_{ij} = r)$ are the probability of being in category r; $\beta_0^{(r)}$ are constant terms; $\beta^{(r)} = (\beta_1^{(r)}, ..., \beta_R^{(r)})'$. Both $\beta_0^{(r)}$ and $\beta^{(r)}$ are considered to be fixed effects. The $R - 1$ random effects $u_j^{(r)} = (u_{2j}, ..., u_{Rj})'$ are assumed to follow a multivariate normal distribution with mean 0 and covariance matrix Ω_u, where

$$\Omega_u = \begin{bmatrix} \sigma^2_{u2} & & & \\ \sigma_{u23} & \sigma^2_{u3} & & \\ \vdots & \vdots & \ddots & \\ \sigma_{u2R} & \sigma_{u3R} & \dots & \sigma^2_{uR} \end{bmatrix}$$

The σ^2_{ur} measures the cluster-level variances on the odds of being in response category r rather than the reference category 1 (e.g., $\sigma^2_{ur} > 0$ indicates the presence of unmeasured cluster-level factors), while the covariances (the off-diagonal terms in Ω_u) measures the correlation between the cluster-level factors of the different response categories.

From model (2.8), we can calculate the predicted probability of response outcome r for individual i in cluster j as

$$\hat{\pi}^{(r)}_{ij} = \frac{exp(\hat{\beta}^{(r)}_0 + \hat{\beta}^{(r)} x'_{ij} + \hat{u}^{(r)}_j)}{1 + \sum_{l=2}^{R} exp(\hat{\beta}^{(l)}_0 + \hat{\beta}^{(l)} x'_{ij} + \hat{u}^{(l)}_j)} \tag{2.9}$$

where $\hat{\beta}^{(r)}_0$, $\hat{\beta}^{(r)}$ and $\hat{u}^{(r)}_j$ are sample estimates of $\beta^{(r)}_0$, $\beta^{(r)}$ and $u^{(r)}_j$. The probability of the reference category $\hat{\pi}^{(1)}_{ij}$ is calculated by subtracting the sum of the response probabilities of all other categories from 1 (i.e., $\hat{\pi}^{(1)}_{ij} = 1 + \sum_{l=2}^{R} \hat{\pi}^{(1)}_{ij}$).

To assess how well the model fit the data, the Deviance Information Criterion (DIC) diagnosis was used. For multinomial models, the formula is

$$D = -2 \sum_{i} \sum_{r=1}^{R} [I(y_i = r) \hat{\pi^{(r)}_i}] \tag{2.10}$$

where $I()$ is an indicator function which returns 1 if the condition is satisfied (i.e., if individual i belongs to category r); and $\hat{\pi}^{(r)}_i$ is the predicted probability of being in category r for individual i. We finally fitted the multilevel multinomial logistic regression models in a Bayesian framework.

We used several statistical and Geographic Information Systems (GIS) software packages for data extraction, analysis, and mapping; notably, R, STATA, MLwiN, WinBUGS, QGIS and ArcGIS were used.

Chapter 3

Are Droughts Bigger Drivers of Child Undernutrition than Conflicts in Ethiopia? Testing the Power of Small-scale Surveys

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This chapter is adapted from:
Tefera Darge Delbiso, Jose Manuel Rodriguez-Llanes, Anne-Françoise Donneau, Niko Speybroeck, Debarati Guha-Sapir: "Drought, conflict and children's undernutrition in Ethiopia 2000–2013: a meta-analysis." *Bulletin of the World Health Organization 02/2017*; 95(2):94-102.
http://www.who.int/bulletin/volumes/95/2/16-172700

Abstract

Background: *Child undernutrition remains an important public health challenge in Ethiopia. The problem is worse in the emergency pockets within the country where climate shocks and conflicts exacerbate food insecurity. Against this backdrop, our aim was to estimate the burden of acute malnutrition among children aged 6–59 months and to investigate the effects of drought and conflict on acute malnutrition in crisis-affected areas in Ethiopia.*

Methods: *We searched the Complex Emergency Database for nutrition surveys carried out in Ethiopia over the period 2000–2013. We extracted data on the prevalence of wasting (weight-for-height z-scores below -2) among children aged 6–59 months for regions of Ethiopia. Data on any conflict events (irrespective of magnitude or impact) and episodes of seasonal drought affecting the survey areas were extracted from publicly available data sources. Random-effects Bayesian meta-analysis was used to synthesize the evidence from 231 small-scale surveys.*

Results: *From the total sample of 175,607 children analyzed, the pooled number of children wasted was 21,709. The posterior median prevalence of wasting was 11.0% (95% credible interval, CrI: 10.3–11.7) over the 14-year period. Compared with areas unaffected by drought, the estimated prevalence of wasting was higher in areas affected by moderate levels of drought (posterior odds ratio, OR: 1.34; 95% CrI: 1.05–1.72) but similar in severe drought-affected areas (OR: 0.96; 95% CrI: 0.68–1.35). Although the pooled prevalence of wasting was higher in conflict-affected than unaffected areas, the difference was not plausible (OR: 1.02; 95% CrI: 0.82–1.26).*

Conclusions: *Despite an overall declining trend, a wasting problem persists among children in Ethiopia. Conflict events did not have a major impact on childhood wasting. Nutrition interventions should go beyond severe drought-prone areas to incorporate areas where moderate droughts occur.*

3.1 Introduction

Since 1990, considerable progress has been made towards improving child health in the world [5, 6]. Nonetheless, worldwide 52 million children younger than five years had acute malnutrition [5] and 5.6 million children died in 2016 [6]. The burden is particularly heavy in Africa, where conflict, political fragility and drought are more prevalent [23]. These events affect food security and nutrition by limiting food accessibility, impacting health services and disturbing the care structure within the society [9, 124]. Several studies have documented the negative effect of conflict [29, 50, 124–127] and drought [29, 66] on child health and nutrition.

Ethiopia has been affected by drought and starvation on a large scale since the mid-1980s. Untimely, abnormally low and infrequent rainfall has been increasing the frequency and impact of droughts in recent years [128]. Drought is the most complex and detrimental natural hazard and has a substantial impact in countries, such as Ethiopia, where the economy and livelihood are predominantly dependent on subsistence rain-fed agriculture [128]. The country has also experienced several conflicts, both within the country and with neighbouring states, particularly Eritrea and Somalia [129]. Nevertheless, in the decade 2000–2011, the country showed improvements in key economic and development indicators [130, 131] and in 2014 Ethiopia was on track to achieve six of the eight MDGs [81]. Yet child undernutrition is still a concern, with an estimated 4,819,770 (40%) of the child population of 12,049,424 being stunted and about 1,084,448 (9%) being wasted in 2014 [132]. According to the Cost of Hunger in Africa study [133], undernutrition in Ethiopia was responsible for an estimated 378,591 child deaths in 2005–2009 (28% of all child deaths), 152,488 primary school repititions in 2009 (16% of all repititions), an estimated cost of 4.7 billion USD in 2009 (16.5% of the country's GDP) and an absent of 3.2 million people of working age due to undernutrition-induced child mortality in 2009 alone (8% reduction in the total workforce). The problem of undernutrition is worse in crisis-affected areas within the country, where food insecurity is heightened due to climate shocks and conflicts [59, 125].

Although several small-scale surveys have been conducted by humanitarian organizations in crisis-affected areas, we only found one study which investigated the associations among child undernutrition, conflict and variability in the general ecosystem in East Africa including Ethiopia [127]. Wasting reflects recent weight loss and has been shown to be a good predictor of child mortality [55]. Consequently, it is a preferred index of nutritional status in humanitarian emergencies and a proxy indicator for the general health and welfare of the entire population [124, 134]. Thus, examining the effects of drought and conflict on the prevalence of wasting in children would provide knowledge to guide intervention strategies. Moreover, generated estimates could be a useful baseline for future surveys in crisis-affected areas. We sought to provide summary estimates of the prevalence of wasting among children aged 6–59 months, and investigate the effects of drought and conflict on the prevalence of childhood wasting in regions of Ethiopia which had sufficient data available.

3.2 Data and Methods

We extracted all the data from publically available databases (Table 3.1).

3.2.1 Nutrition data

First, we searched the CE-DAT for all nutrition surveys carried out in Ethiopia from 1 January 2000 to 31 December 2013. CE-DAT compiles data on commonly used health indicators (e.g. nutrition, vaccination and mortality) from small-scale surveys conducted in areas affected by complex emergencies [68, 73]. The Emergency Nutrition Coordination Unit (ENCU) of Ethiopia , a government department, leads the coordination and quality assurance of the surveys in the field [135], while the CE-DAT team validates the surveys before entering the results in the database using the completeness checklist ([68, 73], Appendix A).

Initially, we identified 406 small-scale nutrition surveys. We excluded duplicate studies; studies with non-probabilistic sampling design or unreported sample size; and studies of refugees, internally

TABLE 3.1: **Key characteristics of the databases used in the analysis of the effects of drought and conflict on the prevalence of wasting in crisis-affected areas within Ethiopia, 2000–2013**

Variable	CE-DAT [68, 73]	SPEI Global Drought Monitoring [98, 101]	ACLED [103]	UCDP [104]
Website	http://cedat.be/	http://sac.csic.es/spei/	http://www.acleddata.com/	http://ucdp.uu.se/
Data compiled	Nutrition (e.g. childhood wasting and stunting), mortality and vaccination indicators from areas affected by complex emergencies	Intensity, magnitude, duration and spatial extent of drought episodes	Political violence event data, disaggregated by time, agent, type and space	Event-based georeferenced data set on organized violence
Time coverage	2000–2013	1950–	1997–	1946–
Spatial coverage	50+ developing countries	Global	60+ countries in Africa and Asia	35+ countries in Africa and East Asia
Sample	3309 surveys	SPEI of the globe at a spatial resolution of 0.5 degrees	100000+ conflict events (October 2015)	21860+ violent events (October 2015)
Data sources	Surveys from UN agencies; country clusters; academic institutions; NGOs; ministries of health; and published peer-reviewed journals	Calculated based on climatic water balance using monthly precipitation and temperature data	Media reports; humanitarian agency and NGO reports	Media and research reports; international and multinational agency and NGO documents; and regional experts

displaced persons, returnees (displaced persons who have returned to their place of origin or habitual residence) or mixed populations (refugees, internally displaced persons, and residents living together). Based on our inclusion criteria, we used data from 231 surveys (Figure 3.1).

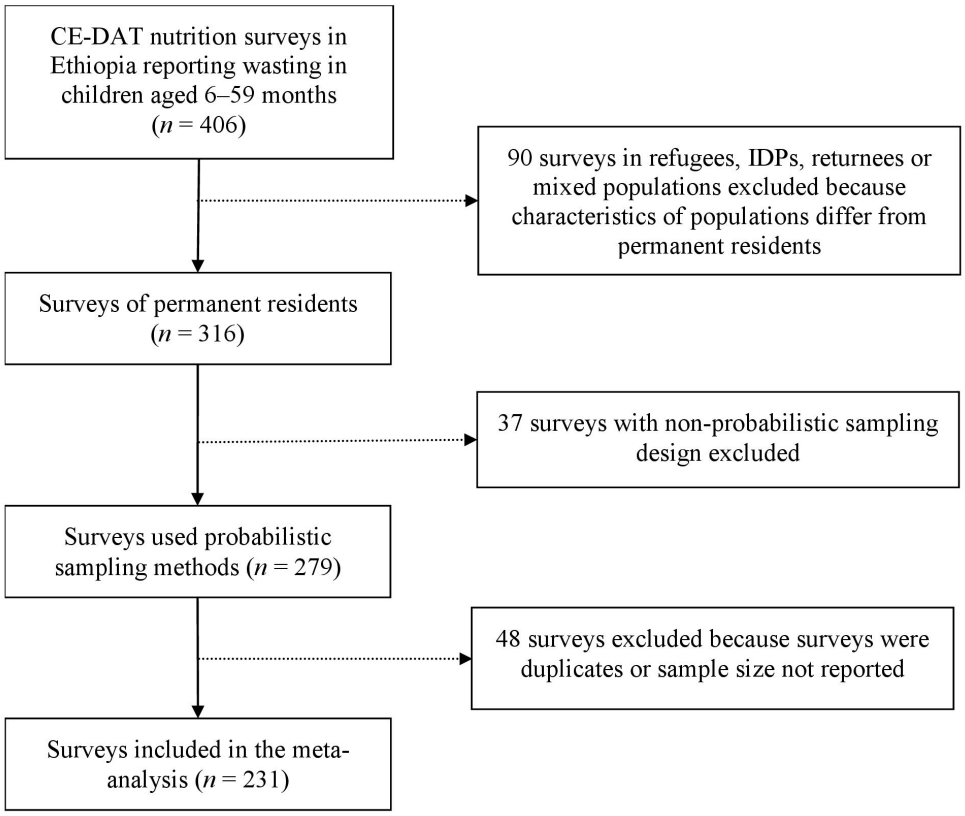

FIGURE 3.1: **Flowchart of small-scale surveys in Ethiopia (2000–2013) included in the meta-analysis.** CE-DAT: Complex Emergency Database. IDP: Internally Displaced Persons.

From these surveys, we extracted data on the prevalence of wasting. Wasting was calculated from weight and height measurements of children aged 6–59 months to produce weight-for-height z-scores. A z-score index below -2 is a sign of acute undernutrition and is defined as wasting [90]. The prevalence of wasting in the surveys was reported in relation to the NCHS reference population or the 2006 WHO standard. To obtain comparable data over time, we converted estimates based on the NCHS standard into the WHO standard using a conversion algorithm [92]. For each survey, we also extracted data on sample size, the

date when the survey commenced, the administrative area names and the centroid GPS (Geographic Coordinate System) coordinates of the study location.

3.2.2 Conflict events data

We compiled data on any conflict events affecting each survey location. We used two sources: the ACLED and the UCDP Armed Conflict Dataset (Table 3.1). ACLED contains georeferenced data on political violence and protests [103], while UCDP provides information on armed conflicts in which the use of armed force between two parties (at least one of which is the government of a state) results in at least 25 battle-related deaths in a year [104]. Both ACLED and UCDP data are assembled from various primary and secondary sources (e.g., online databases, print media and reports from NGOs, and regional experts) and then aggregated, coded and cross-checked by experienced researchers to assure consistency, accuracy and compatibility with the inclusion criteria [103, 104] (more detail in **Chapter 2 Section 2.2.4**). We combined the two data sets in order to capture all conflict events occurring over the study period. We considered conflict events irrespective of their magnitude or impact, to accommodate smaller conflicts which might have an impact on the livelihood of the population. We created a binary variable to indicate the occurrence of a conflict event (yes/no) in a given location within six months before the survey starting date. The 6-month period was chosen with the assumption that the effects of conflicts may not stay longer than 6-months as the country has been in a relative peace over the study period. Finally, we extracted the specific locations of the conflict events and matched them with the wasting data from CE-DAT in the same GPS location (the centroid) as each survey.

3.2.3 Drought episodes data

We also compiled data on episodes of drought affecting each survey location. We extracted the data from the Global Drought Monitor database. The database provides real-time information about drought conditions at the global scale with a spatial resolution of 0.5° (about 50 km) and a monthly time resolution (Table 3.1). We used the standardized precipitation evapotranspiration index, which is a multi-scalar index used to quantify the precipitation deficit over time and space for different timescales. The index enables identification of the severity of droughts, which is vital information for assessing different responses needed to drought [98, 101] (more detail in **Chapter 2 Section 2.2.2**). We used the 3-month index, which is a short-term or seasonal drought index [101], as wasting is mainly the result of sudden or recent weight loss due to short-term shocks, such as drought. Moreover, the 3-month index better captures drought events affecting agriculture [98, 101]. Thus, the short-term effect of drought on childhood wasting over the preceding three months of a survey could be adequately captured. Positive index values indicate a wet period while negative values indicate a dry period [101].

We categorized the index values as: no drought (value $>$ 0), mild drought (-1 $<$ value $\leq$ 0), moderate drought (-1.5 $<$ value $\leq$ -1) and severe to extreme drought (severe drought hereafter) (value $\leq$ -1.5) [136]. The drought episodes at specific locations in a given period were matched with the wasting data from CE-DAT in the same month and GPS location as each survey.

3.2.4 Statistical analysis

We identified and measured heterogeneity between the surveys using two statistical methods: the between-survey variance (τ^2) and the percentage of variability in effect size due to heterogeneity (I^2) [116]. We then fitted a random effects meta-analysis to address the heterogeneity. To explain the heterogeneity, we further fitted meta-analysis of subgroups and random-effects meta-regression by including study-level covariates (moderators): conflict events, drought episodes, survey years and regions (more detail in **Chapter 2 Section 2.3.2**). We also

tested the interaction effect to assess whether the association between drought and wasting varied by conflict status.

We used a Bayesian approach for meta-analysis to accommodate all parameter uncertainties in the model and to borrow strength from other surveys to improve parameter estimation [111]. As we had compiled a large number of surveys, each of which had a substantial sample size, we wanted our posterior inference to reflect the information in our data set without being influenced by the choice of prior distribution. Consequently, we assigned non-informative prior distributions for the model parameters.

The number of wasted children in a survey, r_i ($i = 1, ..., 231$), was modelled using a binomial distribution: $r_i \sim$ binomial (p_i, n_i), where p_i is the prevalence of wasting in survey i and considered as a random variable and n_i is sample size of survey i. The logit-transformed prevalence was assumed to follows a normal distribution: $logit(p_i) = \mu_i$ and $\mu_i \sim$ normal (μ, τ^2), where μ was the estimated common prevalence and τ^2 was the between-survey variance. The meta-regression model was then formulated by extending the above model to include moderators x_i and is given by $logit(p_i) = \mu_i + \beta x_i$, where β is the slope coefficient. Then non-informative priors were assigned to the parameters: $\mu_i \sim$ normal$(0, 10^6)$, $\beta \sim$ normal$(0, 10^6)$, and $\tau \sim$ gamma$(10^{-3}, 10^{-3})$. We run the chain for 100,000 iterations with a burn-in length of 10,000 iterations to ensure convergence of Markov chain. The convergence was assessed by visual inspection of the trace plots and autocorrelation plots [105].

We report the posterior median estimates of the prevalence of wasting as percentages and the odds ratios (OR) with 95% credible intervals (CrI). Results were judged to be statistically significant (plausible) if the 95% CrI do not overlap 1.0. The statistical analyses were conducted using WinBugs software version 14 (MRC Biostatistics Unit, Cambridge, UK). We used the metafor package [112] from the R statistical software [137] to construct the forest plots.

3.3 Results

3.3.1 Survey locations

Figure 3.2 presents the geographic distribution of the surveys included in the analysis. The surveys covered seven of the eleven Ethiopian administrative regions. Most of the surveys were from the three largely populated administrative regions: Oromia (75; 32.5%), SNNP (66; 28.6%), and Amhara (50; 21.6%). Further details of the surveys are available in the Appendix B.

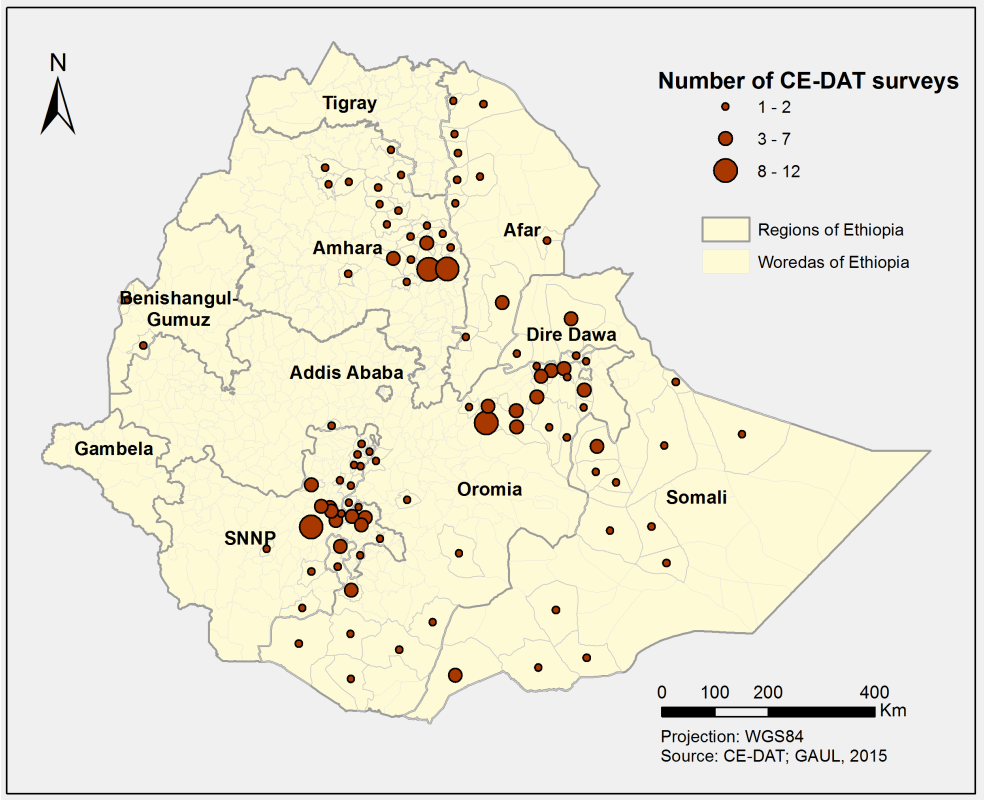

FIGURE 3.2: **The number of CE-DAT surveys (*n=231*) included in the meta-analysis by *woredas* and regions of Ethiopia, 2000–2013.**

3.3.2 Summary of the survey characteristics

Figure 3.3 presents a summary of the characteristics of the surveys. A total of 231 small-scale surveys estimating wasting in a sample of 175,607 children aged 6–59 months over the 14-year period were used

in the analysis. The sample sizes ranged from 300–1227 children per survey. The dates of the surveys were distributed as follows: 67 (29.0%) were conducted between 2000 and 2004, 97 (42.0%) between 2005 and 2009, and 67 (29.0%) between 2010 and 2013 (Figure 3.3).

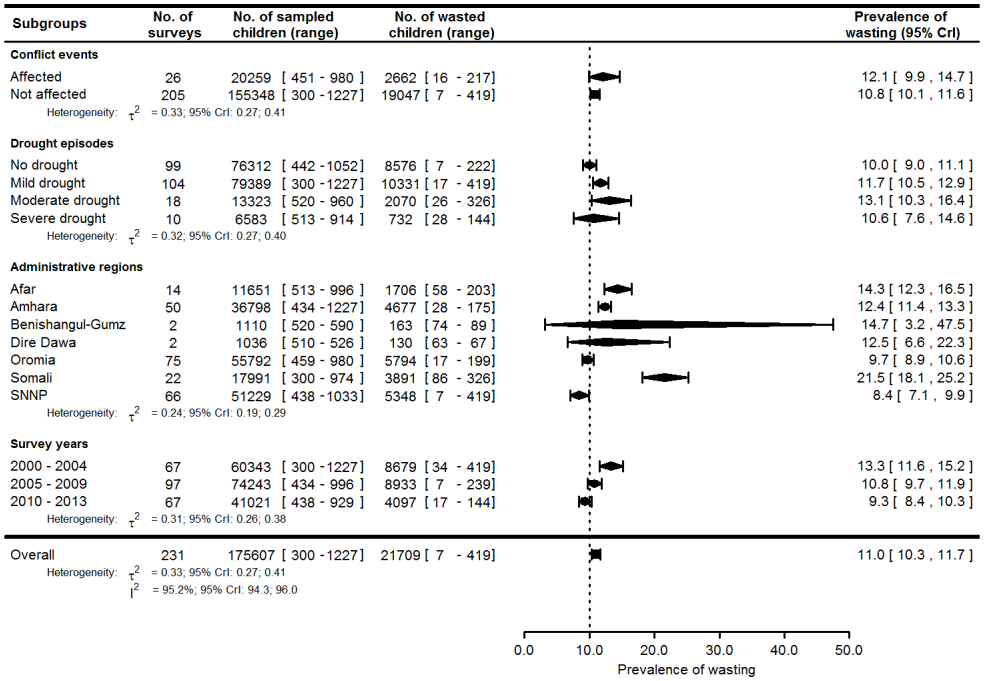

FIGURE 3.3: **Summary of the pooled prevalence of wasting among children 6–59-month-old from 213 surveys in crisis-affected areas within Ethiopia, 2000–2013.** Wasting was defined as weight-for-height z-scores below -2, standardized to WHO reference [92]. Prevalence was the posterior median estimates of wasting, expressed as percentages of the number of children in each category, with their 95% CrI. Conflict events were occurrence of a conflict in a given location within six months of the survey starting date, irrespective of magnitude or impact. Data from the ACLED [103] and the UCDP [104] were combined into a binary variable. Drought episodes in a given location were based on the 3-month SPEI from the Global Drought Monitor database [98]: no drought (SPEI > 0), mild drought (-1 < SPEI $\leq$ 0), moderate drought (-1.5 < SPEI $\leq$ -1) and severe drought (SPEI $\leq$ -1.5). CrI: credible interval.

We ascertained that 26 (11.3%) of the surveys, involving a pooled number of 20,259 children, were conducted in areas affected by some kind of conflict in the six months before the surveys; 155,348 children lived in areas where no conflicts were recorded. 132 (57.1%) of the surveys were from areas affected by mild to extreme drought three months before the survey implementation month. The pooled numbers of children affected by mild drought were 79,389, moderate drought 13,323, and severe drought 6583; a total of 76,312 children were living in areas where no episodes of drought were recorded. Overall, a total of 21,709 children were affected by wasting and the estimated pooled prevalence from the 231 surveys was 11.0% (95% CrI: 10.2–11.7). Moreover, 143 of the surveys (61.9%) reported a wasting prevalence of greater than 10%. The heterogeneity statistic ($\tau^2 = 0.33$) and ($I^2 = 95.2\%$) showed a large variability across the surveys compiled (Figure 3.3).

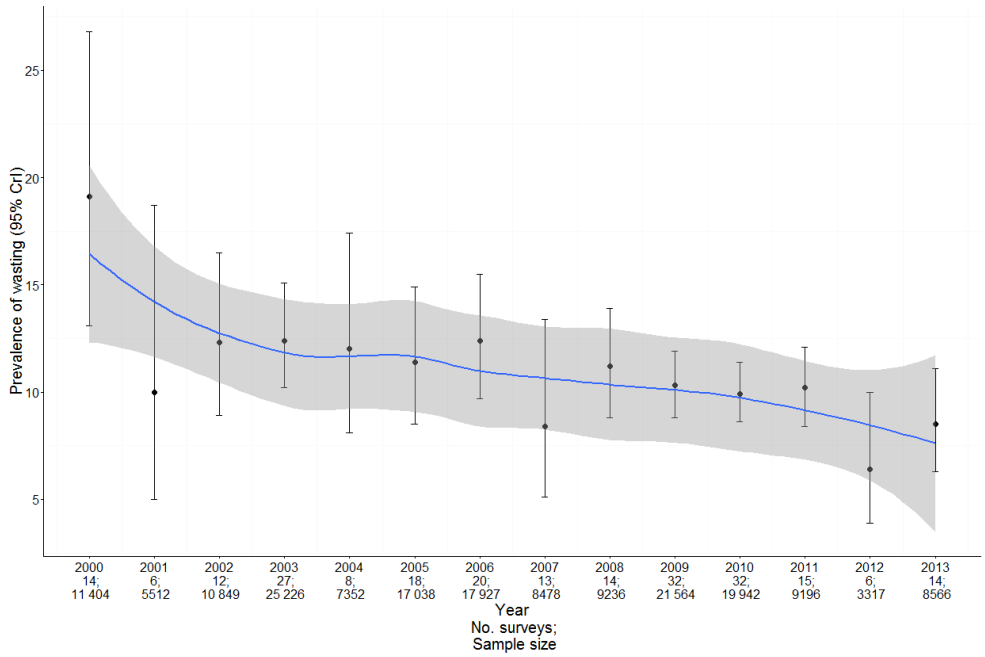

FIGURE 3.4: **Trends in the prevalence of wasting among children 6–59-month-old from 213 surveys in crisis-affected areas within Ethiopia, 2000–2013.** Wasting was defined as weight-for-height z-scores below -2, standardized to WHO criteria [92]. Prevalence was the posterior median estimates of wasting, expressed as percentages of the number of children in each year. The smoothed line is the local polynomial regression fit and the shaded region is its 95% confidence interval. CrI: credible interval.

The highest regional prevalence was observed in Somali region (21.5%), where a total of 3891 children were affected by wasting, and the lowest was in SNNP region (8.4%; 5348 children). The pooled prevalence of wasting was estimated to be 13.1% among children living in areas affected by moderate drought (a pooled total of 2070 children) and this was higher than in areas with no drought (10.0%; 8576 children). In areas affected by severe drought, the estimated prevalence of wasting was similar (10.6%; 732 children) to that in areas unaffected by drought. The estimated prevalence of wasting was 12.1% (a pooled total of 2662 children) in conflict-affected areas and 10.8% in areas unaffected by conflict (19,047 children) (Figure 3.3). The estimated prevalence of wasting decreased steadily over the study period from 19.1% (2233 children) in 2000 to 8.5% (817 children) in 2013 (Figure 3.4); or from 13.3% in the 2000–04 to 9.3% in 2010–13 (Figure 3.3).

3.3.3 Meta-regression analysis

In survey areas affected by moderate drought the odds of the prevalence of wasting were higher than in areas unaffected by drought (OR: 1.34; 95% CrI: 1.05–1.72; Table 3.2), whereas in areas affected by severe drought there was no difference compared with unaffected areas (OR: 0.96; 95% CrI: 0.68–1.35). Conflict in the survey area had no plausible effect on the odds of the prevalence of wasting (OR: 1.02; CrI: 0.82–1.26). A one-year increase in the survey period reduced the odds of the prevalence of wasting by 4% (OR: 0.96; 95% CrI: 0.94–0.98) (Table 3.2). We reported the model without interaction, as the interaction between drought and conflict was found to be implausible.

TABLE 3.2: **Results of meta-regression from 213 surveys of the prevalence of wasting among children aged 6–59 months in crisis-affected areas within Ethiopia, 2000–2013.**

Category	Posterior OR (95% CrI)
Conflict events affecting survey area[a]	
No	Ref.
Yes	1.02 (0.82–1.26)
Drought episodes affecting survey area[b]	
None	Ref.
Mild	1.04 (0.91–1.19)
Moderate	1.34 (1.05–1.72)
Severe	0.96 (0.68–1.35)
Survey year[c]	0.96 (0.94–0.98)
Administrative region of survey	
Afar	1.51 (1.15–2.00)
Amhara	1.29 (1.08–1.54)
Benishangul-Gumz	1.61 (0.80–3.26)
Dire Dawa	1.53 (0.75–3.13)
Oromia	Ref.
Somali	2.21 (1.74–2.81)
Southern, Nations and Nationalities People's	0.82 (0.69–0.97)

OR: odds ratio; CrI: credible interval; Ref.: reference group.
[a] Conflict events were occurrence of a conflict in a given location within six months of the survey starting date, irrespective of magnitude or impact.
[b] Drought episodes in a given location were based on the 3-month SPEI.
[c] For a one-year increase in the survey period.
Note: Data were estimated from a pooled sample of 175,607 children. See Figure 3.3 for the number of surveys, samples sizes, numbers of children affected and prevalence of wasting by category. Wasting was defined as weight-for-height z-scores below -2.

3.4 Discussion

Here we present estimates of the prevalence of childhood wasting in crisis-affected areas within Ethiopia, using pooled data from 231 small-scale surveys. We used a Bayesian approach to meta-analysis to improve estimates by taking into account all parameter uncertainties and borrowing strength from all available surveys. Overall, the pooled prevalence of wasting was 11.0% and showed a decreasing trend over the 14-year period covered in the meta-analysis. In nearly 62% of the surveys the prevalence of wasting exceeded WHO's 10% threshold for an emergency response, an indication of a serious concern for child nutrition [134]. In the meta-regression analysis, we also showed that moderate drought-affected areas had a higher prevalence of wasting than areas unaffected by drought. Conflict in an area, however, was not associated with wasting.

Three results are worth highlighting. First, the prevalence of wasting declined over the period of the study. Economic growth in a country alleviates poverty thereby reducing the risk of hunger and malnutrition [9]. In the decade 2000–11, Ethiopia's average GDP grew by over 10% annually [130] and the population living below the national poverty line declined from 44% in 2000 to 30% in 2011 [131]. Therefore, population below the minimum dietary energy consumption dropped from 41.9% in 2000 to 33.6% in 2011 [81]. The country achieved the MDG target of reducing extreme hunger by half [9]. Ethiopia launched a national nutrition strategy in 2008 with the aim of improving food and nutrition security. The different programmes that are in place to improve nutrition practices [132] – including health education, provision of micronutrients and treatment of malnourished children – could explain the declining trend of childhood wasting found in our study. Despite these improvements in development and a commitment and investment in nutrition interventions in Ethiopia, we found that the prevalence of wasting in crisis-affected areas was high. In particular, Somali, Afar and Amhara regions had higher prevalence than other areas. This could be due to the higher food insecurity problems in parts of the regions as a result of recurrent droughts and land degradation [59].

Second, although the link between drought and nutrition is well recognized, it is often indirect and complex. The quality and quantity of nutrient intake is affected by reduced food production as a result of drought [66]. Our results showed that the prevalence of wasting was 34% higher in areas affected by moderate drought relative to non-affected areas, whereas no such difference was observed in areas affected by severe drought. In 2005, the Ethiopian government, in collaboration with partner organizations, launched the Productive Safety Net Programme (PSNP). The programme aimed to ensure food supplies to chronically food-insecure areas that are highly vulnerable to climate shocks [138]. Hence, areas affected by severe drought are more likely to benefit from the programme and this might explain why no effect on wasting was seen in these areas. Furthermore, the country's early warning system [139] and other humanitarian activities, which targets the areas affected by severe drought, may also help mitigate the impact of severe droughts. Our results underscore the need for interventions to go beyond predefined severe drought-prone areas, with strengthening of early warning systems and intervention programmes to benefit people living in moderate drought-prone areas too. On the other hand, if we hypothesize that there is a potentially high mortality among children in areas affected by severe drought, survival bias might explain the similar prevalence of wasting in severe drought-affected areas and unaffected areas. This assumption is corroborated by a study that found drought-affected areas experienced higher child mortality in the 2002–03 drought in Ethiopia [140]. Unfortunately, the mortality and cause of death data in the studied surveys were not detailed enough to test our assumptions and to provide a more holistic view of the drought impact on mortality.

Third, conflict and a high prevalence of acute undernutrition are reported to be associated [141]. Conflict triggers food insecurity and affects nutrition through disrupting crop production; destroying food stores and livestock; forcing people to eat food with lower nutritional value; affecting market food supply and price inflation; pushing people to live in unhealthy environments; impacting health services; and affecting productivity and family care structures [9, 124, 142]. However, in our meta-analysis, we found no evidence of a difference between

the prevalence of wasting in areas affected and unaffected by conflict. The effect of conflict on livelihood and nutrition depends on the nature, magnitude and duration of the conflict [142]. In our study, most of the conflict events which occurred during the specified time period were short-lived (mostly one day) and of low magnitude (mainly no fatalities). They may therefore not have had a major impact on the nutrition situation of the community in general and children in particular. Our finding is supported by previous studies [127, 143], which found no association between the prevalence of wasting and exposure to conflict events.

Our study had limitations. First, we compiled surveys that were conducted by different organizations for practical and operational purposes; hence the survey results are rarely peer-reviewed, and sharing or publication bias cannot be ruled out [68, 73]. However, most of the surveys used standardized methods, the SMART methodology [96]. Furthermore, CE-DAT is a unique and well-established data source for nutrition and mortality indicators in humanitarian emergencies [68, 73]. Second, while the assessment of CE-DAT coverage is a future area for improvement of the database [68, 73], the surveys are representative of small geographical areas, a key characteristic to ascertain the small-scale impact of drought and conflict on nutrition. Third, potential underlying determinants (e.g. coping strategies, diseases and food and non-food interventions) [141] which could explain part of the observed variability are not available in CE-DAT. Fourth, the locations for conducting the surveys were likely influenced by suspicions of higher levels of undernutrition. However, our aim here was not to assess malnutrition levels in the country but in crisis-affected areas within Ethiopia. Fifth, the ACLED and UCDP databases mainly collect conflict event data from the media, online journals and NGO's reports [103, 104]. These could introduce reporting bias (selective reporting or omissions) for political or other reasons. To reduce the bias, we combined the two databases and also considered only the occurrence of conflict, as data on the impact of conflicts (e.g. deaths) are more likely to suffer from reporting bias from different organizations. Although these limitations constrain our study's ability to fully explain the links between drought or conflict and nutrition, the findings still provide evidence to

support policies and programmes designed to mitigate the health effects of drought and conflict.

3.5 Conclusions

The pooled prevalence indicates a persistent childhood wasting problem in Ethiopia. Therefore, national nutrition strategies should target areas of persistent undernutrition. Although areas affected by severe drought must remain a national priority for specific targeted actions, nutrition policy should consider interventions that go beyond the predefined severe drought-prone areas and incorporate areas where moderate droughts occur.

Acknowledgments

We thank Chiara Altare and all agencies that conducted the surveys and shared their reports with the CE-DAT team. Association pour l'Epidemiologie de Désastres, UCL, and Fond National de Recherche Scientifiqu (FNRS) supported this work.

Chapter 4

Droughts and Child Mortality in Ethiopia: Can Small-scale Surveys Tell us More About the Mitigation Efforts?

This chapter is adapted from:
Tefera Darge Delbiso, Chiara Altare, Jose Manuel Rodriguez-Llanes, Shannon Doocy, Debarati Guha-Sapir: "Drought and child mortality: a meta-analysis of small-scale surveys from Ethiopia." *Scientific Reports 05/2017*; 7:2212.
https://www.nature.com/articles/s41598-017-02271-5

Abstract

Background: *Despite the intuitive connection between drought and mortality, we still lack a sound quantitative synthesis of evidence drawn from the available data. In this study, we estimated the pooled U5DR and assessed the effect of drought on child deaths in Ethiopia.*

Methods: *Small-scale mortality surveys were searched from the Complex Emergency Database and then aggregated spatially and temporally with drought exposure data from the Global Drought Monitor and food insecurity data from the Famine Early Warning Systems Network. A Bayesian Poisson meta-analysis was performed on 88 surveys conducted in Ethiopia between 2009 and 2014, consisting of 55,219 under-five children.*

Results: *The pooled U5DR was estimated at 0.323/10,000/day (95% credible interval, CrI: 0.254–0.397), which is below both the emergency and the baseline death rate thresholds of sub-Saharan Africa. This finding was still robust when we exclude surveys with zero death counts. We failed to find a plausible association between drought and U5DR. However, minimal food-insecure areas showed elevated U5DR compared to stressed food-insecure areas. Furthermore, the U5DR increases as the prevalence of acute malnutrition increases.*

Conclusions: *Targeted interventions to improve the underlying causes of child malnutrition are crucial. Further, revising and updating the existing mortality thresholds, both the baseline and the emergency, is recommended.*

4.1 Introduction

Humanitarian emergencies, which are mainly triggered by either civil conflicts or natural disasters, undermine the livelihood and health of the affected population and increase mortality [2]. Drought is a natural and cyclical event that develops slowly, worsens gradually, and results in destitution, starvation and death if not addressed properly. Between 1994 and 2013, more than one billion people were affected by drought worldwide. Africa, accounting for 41% of all drought events, suffered more frequent droughts than any other continent [16]. The health impact of drought is complex and long lasting. Drought has been associated with excess mortality through inducing nutrition and health problems, such as undernutrition, micronutrient deficiencies, food- and water-borne diseases; aggravating chronic diseases; declining crop and livestock production; contributing to inflation of food prices; and triggering drought-induced migration (Figure 1.6). When combined with poverty, weak health infrastructure and poor sanitation, its impact is even worse [65, 66].

Ethiopia is prone to weather-related shocks, such as droughts and floods. As a result, the country has been experiencing recurrent droughts and food shortages since the 1950s. More than 80% of its population are dependent on subsistence and rain-fed agriculture, meaning that the majority of the population is highly vulnerable to drought [144]. The most severe of which was the mid-1980s famine, in which, even with a massive humanitarian response, elevated malnutrition prevalence was observed and an estimated 700,000 excess deaths occurred [35, 145]. Despite the noticeable improvements in the overall development and the achievement of the MDG target of reducing hunger by half between 1990 and 2015 [81], every year, a significant portion of Ethiopians rely on food assistance mainly due to recurrent droughts. For example, in 2015–16, following the devastating impact of El Niño weather events, Ethiopia experienced one of the worst droughts in the last five decades. Consequently, more than 10 million people (> 10% of the total population) were in need of urgent food assistance [60].

Pooled data investigating the effects of drought on child mortality are scarce in crisis-affected areas. A recent systematic review by Stanke and colleagues pointed out the lack of sound quantitative syntheses on the drought-mortality link, possibly due to the differences between studies in regard to settings, methods and outcomes measured [66]. The few available studies have focused on the immediate causes of malnutrition and mortality in complex emergencies, which include inadequate dietary intake and diseases, such as diarrheal diseases, acute respiratory infections, measles, malaria, and severe malnutrition [146, 147]. On the other hand, a more comprehensive study by Checchi and Robinson [148] detected a very large number of excess mortality attributable to the 2010-12 severe food insecurity and famine in Somalia. However, only one study investigated the relationship between drought and child survival in Ethiopia and this was conducted in the 2002/03 drought [140]. No difference in child mortality was observed between drought affected and non-affected areas; however, study limitations, such as not considering drought intensity and the one-year time elapse between the drought occurrence and when the study was conducted, may have contributed to null findings [140]. To address this research gap and provide a sound quantitative synthesis, we explored the effects of drought on child mortality in Ethiopia between 2009 and 2014 considering real-time data on the intensity of drought exposure. The specific aims of the study were to provide a pooled estimate of the U5DR, and to investigate the effect of drought on child death while controlling for the possible contextual factors identified based on the conceptual framework of drought-mortality link (Figure 1.6) and available data. These factors include GAM, MCV, food insecurity, and livelihood zones.

4.2 Data and Methods

4.2.1 Under-five death, nutrition and vaccination data

In the absence of functioning vital registration systems in crisis-affected areas where an elevated prevalence of acute malnutrition and mortality rates are of concern, mortality information is often gathered through retrospective household surveys [149]. Among them are small-scale operational surveys, which are conducted by humanitarian organizations in crisis-affected areas. Small-scale surveys have been shown to be a useful source of information for humanitarian decision making [68]. These surveys are publically available in the CE-DAT, http://www.cedat.be. For the current study, we used surveys conducted in Ethiopia between January 2009 and December 2014. The timeframe for the study was based upon data availability for the contextual factors considered in our analytical framework.

The CE-DAT mainly compiles surveys on nutrition, mortality and vaccination coverage from humanitarian organizations, health ministries and UN agencies. Most of the included surveys follow a standardized methodology for nutrition and mortality surveys, the SMART methodology [96]. Within Ethiopia, the survey process is monitored by the Emergency Nutrition Coordination Unit. The survey reports are further validated by the CE-DAT team using the established completeness checklist (Appendix A), prior to entering the survey results into the database [68]. The following indicators were extracted from the CE-DAT: number of under-five deaths, number of under-five children and the U5DR; the prevalence of GAM among children 6-59 months of age, also referred to as wasting; the MCV coverage among children 9-59 months of age; the survey coverage area (the third administrative level, '*woreda*') in addition to the month and year the survey took place (see the Supplementary Table in Appendix C).

The U5DR reported in the CE-DAT, expressed as deaths per 10,000 children per day (i.e., deaths/10,000/day), were calculated using the number of deaths in children under-five years of age, the total number of under-five children in the population, and the recall period. The prevalence of GAM was calculated based on z-scores of weight and

height measurement of children aged 6–59 months. The weight-for-height z-score below –2 is indicative of wasting [90]. The MCV coverage was based on vaccination cards. If this was not available, it was based on caregiver's recall. Then it was calculated as the number of children vaccinated against measles over the total number of children aged 9-59 months eligible for vaccination.

4.2.2 Drought exposure data

Different indices have been developed to quantify, monitor and analyse drought (e.g., the Palmer drought severity index, the standardized precipitation index, and the standardized precipitation evapotranspiration index) [101] (more detail in **Chapter 2 Section 2.2.2**). We used the SPEI, which is an improved index to identify the spatial and temporal extent of drought exposure and its intensity. The SPEI is calculated for different time-scales (e.g., 1-, 3-, 6-, 12-month) considering the combined effect of precipitation and temperature. For example, a 3-month SPEI obtained at the end of August compares the precipitation and temperature total of June, July and August period with the same 3-month period over historic records (i.e., 1950 onwards). Shorter time-scales (e.g., 3- and 6-month SPEI) identify more frequent droughts of shorter duration affecting agricultural practices, whereas longer time-scales (e.g., 12- and 24-month SPEI) detects less frequent but longer-lasting droughts associated with water resource [98, 101]. The different time-scales are therefore important for assessment of drought effects on child mortality, as the effects are likely to vary with the frequency and duration of droughts. Thus, in this study the 3-month and 12-month SPEIs were used to identify the short- and long-term droughts, respectively.

The SPEI data was downloaded from the Global Drought Monitor, `http://sac.csic.es/spei/map/maps.html`, which provides robust information about drought conditions at the global-scale with 0.5° spatial resolution and monthly time resolution. The SPEI values for a specific location and month were extracted based on the starting time and the centroid of the survey coverage area. The SPEI takes positive or negative values, typically in the range between -2.5 and +2.5, indicating wet- or dry-conditions, respectively [98]. For ease of interpretation, we categorized the SPEI values into: no drought (SPEI $>$ 0), mild drought

(-1 < SPEI $\leq$ 0), moderate drought (-1.5 < SPEI $\leq$ -1) and severe to extreme drought (severe drought hereafter) (SPEI $\leq$ -1.5) [136].

4.2.3 Food security and livelihood zone data

Food security encompasses availability, accessibility, utilization and stability of food for a healthy and active life [9] (more detail in **Chapter 2 Section 2.2.3**). We obtained the food security data from the FEWS NET, http://www.fews.net/, which provides evidence-based analysis on early warning and food insecurity. The FEWS NET uses the IPC, a set of tools and procedures which serve to identify and classify the severity of food insecurity. The IPC is based on the four pillars of food security analysis: accessibility, availability, utilization and stability, and it classifies areas with food insecurity into five phases – minimal, stressed, crisis, emergency, and famine [57]. We gathered historical food security phase data from the FEWS NET quarterly food security reports. Data was available for 81 survey areas from 2009 onwards. In addition, we obtained the livelihood zone classification data (cropping, agro-pastoral and pastoral) from FEWS NET. Livelihoods are based on similarities in terms of economic activity, food source, and income and market opportunities. The food security phase and livelihood zones data of a given survey coverage area were then matched with CE-DAT data using the GPS coordinate.

4.2.4 Statistical analysis

For surveys that did not report the number of under-five deaths, it was calculated by multiplying the mortality rate with sample size and recall period. The datasets were merged across space and time and then random-effects meta-analysis model was fitted to summarize survey results and explore heterogeneity across independently conducted but methodologically similar small-scale surveys. Summarizing data with this approach increases statistical power to detect effects and improve precision [111] (more detail in **Chapter 2 Section 2.3.2**). When applied in humanitarian decision making, the analytical approach can strengthen informed response and preparedness thereby enhancing evidence-based decision-making at large scale [68, 143, 150].

We explored the variability across the survey estimates using the τ^2 statistic (the between-survey variance). To explain the variability, meta-analyses were performed on subgroups based on survey-specific contextual factors or moderators (drought exposure levels, food insecurity, and livelihood zones); and subsequently a meta-regression was fitted adjusting for additional moderators, prevalence of GAM and MCV coverage. We also tested the interaction effects to assess whether the association between drought and U5DR varied by the moderators. Among the 88 surveys included in our meta-analysis, 16 (18.2%) had zero counts for the number of under-five deaths. Using the inverse-variance methods for such data is problematic because the estimates and their variances are not defined for zero death counts. Hence, Poisson regression model for meta-analysis was used as a remedy to circumvent these issues [151]. The model was then fitted in a Bayesian framework in an attempt to incorporate all uncertainties in estimating the parameters and to benefit from its flexibility for inference [105]. In order to assess the potential underestimation of the pooled U5DR estimate due to zero death counts, we run a subset analysis by excluding surveys with zero under-five deaths.

Assume that the observed number of under-five deaths in survey i, $d_i (i = 1, ..., 88)$, follows a Poisson distribution with λ_i (expected number of under-five deaths in survey i). A random-effects meta-analysis using Poisson regression is then expressed as:

$$
\begin{aligned}
d_i &\sim Poisson(\lambda_i) \\
log(\lambda_i) &= \mu_i + \beta_i x_i + log(n_i) \\
\mu_i &\sim Normal(\theta, \tau^2)
\end{aligned}
$$

where μ_i represents the under-five death rate in survey i, θ represents the pooled under-five death rate, τ^2 is the between-survey variance, $x_i's$ are the survey-specific moderators, $\beta_i's$ are the regression coefficients, and the number of under-five children in survey i, n_i, is included as log offset in the model. The unknown parameters were assigned vague *priors* to allow the results to be based on the data: $invese - gamma(10^{-3}, 10^{-3})$ for the variance parameter, τ^2; and $Normal(0, 10^6)$ for θ and $\beta_i's$. The Bayesian meta-analysis was performed in WinBugs

version 1.4 [152], where MCMC sampling is used to make inference. We run the Markov chain for 50,000 iterations after a start-up run of 10,000 iterations. We then assessed the convergence of the chain visually inspecting the trace- and autocorrelation-plots [105]. The metafor package [112] in R statistical software [137] was used to generate the forest plot.

Two meta-regression models were fitted based on the duration of droughts: Model 1 investigating the effect of short-term droughts on child mortality, while Model 2 focused on the long-term droughts, both adjusted for the survey-specific moderators. Finally, the median of the posterior distribution was calculated to provide estimates of the U5DR, Death Rate Ratios (DRR), and 95% CrI derived from the 2.5^{th} and 97.5^{th} percentiles. The statistical significance (plausibility) was judged based on the non-inclusion of 1.0 in the 95% CrI.

4.3 Results

4.3.1 Identification and selection of surveys

We initially extracted 142 small-scale surveys reporting under-five deaths from the CE-DAT. The surveys were conducted between January 2009 and December 2014 by humanitarian agencies operating in Ethiopia. The following inclusion criteria were applied to select surveys for the final meta-analysis: (i) surveys conducted in permanent resident populations; (ii) surveys based on probability sampling methods (simple random sampling, systematic sampling, or cluster sampling); (iii) surveys based on 3-month recall period; and (iv) the U5DR and/or sample size is provided or can be estimated. We excluded surveys conducted in refugee camps, sampling methods not indicated, and recall period not reported. After exclusions, we identified 88 surveys to be included in the meta-analysis (Figure 4.1).

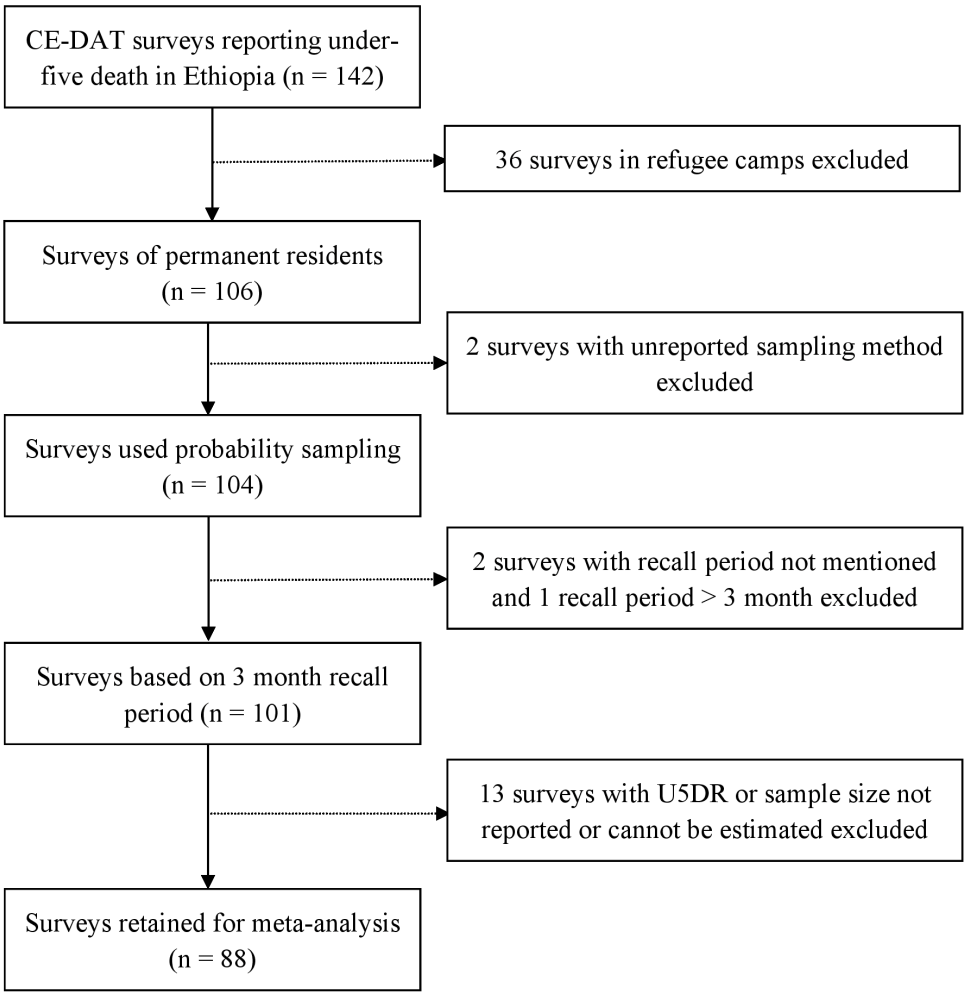

FIGURE 4.1: **Flowchart of the small-scale mortality surveys included in the meta-analysis from Ethiopia, 2009–2014.** CE-DAT: Complex Emergency Database. U5DR: Under-five Death Rate.

4.3.2 Description of the surveys

The 88 surveys included in the meta-analysis consisted of a sample of 55,219 children under-five years of age. The surveys covered 7 of the 11 administrative regions in Ethiopia. Most of the surveys were from the three highly populated regions of the country: Oromia (n=38, 43.2%), Amhara (n=22, 25.0%), and SNNP (n=18, 20.5%) (Table 4.1). The number of children per survey ranges from 239 to 1007. More than a third of the surveys were conducted in 2010 (n=31, 35.2%), while n=4 (4.5%) were conducted in 2014. Supplementary materials on the details of each of the surveys and the contextual factors are

available in Appendix C.

TABLE 4.1: **Description of the 88 small-scale mortality surveys from Ethiopia, 2009–2014.**

Administrative regions	No. of surveys (%)	Sampled children (%)
Oromia	38 (43.2%)	26190 (47.4%)
Amhara	22 (25.0%)	11119 (20.1%)
SNNP	18 (20.4%)	12144 (22.0%)
Afar	5 (5.7%)	2975 (5.4%)
Benishangul-Gumuz	2 (2.3%)	1110 (2.0%)
Dire Dawa	2 (2.3%)	1093 (2.0%)
Gambela	1 (1.1%)	588 (1.1%)
Total	88 (100%)	55219 (100%)

SNNP: Southern Nations, Nationalities and People.

4.3.3 Pooled U5DR, subgroup analysis and meta-regression

The forest plot in Figure 4.2 shows the pooled U5DR according to the subgroups. More than half of the surveys, (n=50, 56.8%) and (n=59, 67.0%), were conducted in areas affected by mild to severe drought in the short- and long-term, respectively. The vast majority of the surveys (n=84, 95.1%) were from stressed or crisis level food-insecure areas, while (n=65, 73.8%) were from cropping areas (versus pastoral and agropastoral) (Figure 4.2).

The pooled U5DR in the study period was 0.323/10,000/day (95% CrI: 0.254–0.397). The heterogeneity among the survey estimates was τ^2=0.38 (95% CrI: 0.17–0.71) (Figure 4.2). When we remove surveys with zero death counts, the pooled U5DR becomes 0.424/10,000/day (95%CrI: 0.351–0.512). The U5DR was not associated with both short- and long-term droughts (Table 4.2). Pastoral areas showed higher U5DR (0.500; 95% CrI: 0.200–1.149) (Figure 4.2), but there was no difference compared to agropastoral areas (Table 4.2) which had U5DR of 0.290 (95% CrI: 0.182–0.443) (Figure 4.2).

Minimal food-insecure areas had a higher U5DR (0.722; 95% CrI: 0.317–1.458) than areas reporting stressed food insecurity (U5DR=0.287; 95% CrI: 0.205–0.388) (Figure 4.2) and the difference was statistically

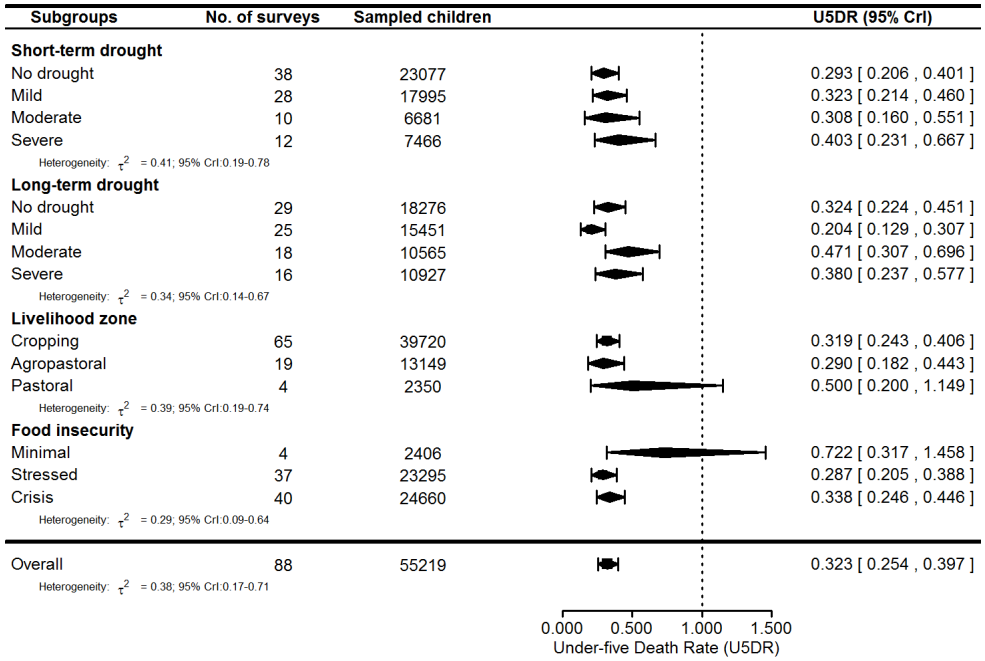

FIGURE 4.2: **Forest plot showing the pooled U5DR and their 95% CrI's, stratified by short- and long-term drought exposure, livelihood zones and food insecurity level from 88 small-scale mortality surveys from Ethiopia, 2009–2014.** The U5DR was based on the small-scale retrospective household surveys [68]. The short- and long-term droughts in a given location were based on the 3- and 12-month SPEI, respectively [101]. Food insecurity was based on the IPC [57]; and it is available for 81 survey locations. Livelihoods are based on similarities in terms of economic activity, food source, and income and market opportunities. CrI: credible interval.

plausible (DRR=2.36; 95% CrI: 1.05–5.02 Model 1; DRR=2.36; 95% CrI: 1.09–4.68 Model 2) (Table 4.2). Every one-percent increase in the prevalence of GAM was associated to an increase of 9% (95% CrI: 4–14%) and 7% (95% CrI: 3–12%) in the median U5DR in Model 1 and Model 2, respectively (Table 4.2). On the other hand, there was no plausible association between U5DR and both MCV coverage and livelihood zones. Further, the interaction between drought and the moderators were implausible. The inclusion of moderators in the meta-regression explained the heterogeneity substantially – the statistic decreased by 50% and 66% for Model 1 and Model 2, respectively (Table 4.2).

TABLE 4.2: **Results from the Bayesian Poisson meta-regression models of the association between child mortality and drought exposures, including covariates, from small-scale mortality surveys in Ethiopia, 2009–2014.**

Variable	Model 1		Model 2	
	Posterior DRR	**95% CrI**	**Posterior DRR**	**95% CrI**
Drought episode				
No drought	Ref			
Mild drought	0.97	0.61; 1.54	0.76	0.44; 1.28
Moderate drought	1.37	0.69; 2.63	1.62	0.98; 2.71
Severe drought	1.27	0.73; 2.26	1.2	0.71; 2.01
Food security				
Minimal	2.36	1.05; 5.02	2.36	1.09; 4.68
Stressed	Ref			
Crisis	1.08	0.72; 1.63	1.14	0.77; 1.69
Livelihood				
Cropping	1.04	0.62; 1.74	1.10	0.67; 1.82
Agropastoral	Ref			
Pastoral	1.25	0.45; 3.45	1.66	0.64; 4.39
GAM	1.09	1.04; 1.14	1.07	1.03; 1.12
MCV	1.00	0.99; 1.01	1.00	0.99; 1.01
Heterogeniety: $\tau^2(95\%CrI)$	0.19 (0.01; 0.54)		0.13 (0.01; 0.44)	

Model 1 investigates the effect of short-term droughts on child mortality, whereas Model 2 investigates the effect of long-term droughts on child mortality, both adjusted for survey-specific moderators (food insecurity, livelihood zones, prevalence of GAM, and MCV coverage). The prevalence of GAM was calculated based on the weight for height z-score index [90]. The MCV coverage was based on vaccination cards and/or caregiver's recall. The statistical significance is based on the non-inclusion of 1.0 in the 95% CrI. DRR: death rate ratios; CrI: credible interval; Ref.: reference category.

4.4 Discussion

Child mortality reflects the general health of the population and is one of the indicators used to benchmark the severity of a crisis [147, 149]. Despite anecdotal and crude evidence on the association between drought and mortality in Ethiopia and elsewhere in the world [66, 145], rigorous synthesis of empirical data is lacking. This could be partly due to the unclear definition of the onset and ending of a drought, its long lasting cumulative effect, and poor record-keeping systems [16, 65, 66]. With the aim of addressing this gap, we conducted a meta-analysis of 88 small-scale mortality surveys (consisting of 55,219 under-five children) from areas affected by humanitarian crises in Ethiopia between 2009 and 2014.

Overall, the pooled U5DR in the study period was 0.323 per 10,000 per day, which is considerably lower than both the emergency threshold death rate of 2.1 and the baseline threshold of 1.07 for sub-Saharan Africa [153]. This conclusion was still robust when we exclude surveys with zero death counts. Ethiopia, in general, has shown great improvement in reducing child mortality and successfully achieved the MDG target of two-thirds reduction in under-five mortality rate between 1990 and 2015 [81]. Consequently, the under-five mortality rate dropped from 166 deaths per 1000 live births in 2000 to 67 in 2016 [84]. This achievement could be attributed to the progress made in improving the coverage of health services and immunization [81, 154].

Crisis-affected areas often show elevated mortality. For example, fragile states in Africa reported 20% higher child mortality compared to low-income countries [23]. However, we obtained a pooled U5DR estimate, which is even lower than the country's average of 0.4/10,000/day, calculated based on the mortality data of UNICEF and the population data of the United Nations population division. Moreover, only 2.3% of the surveys had U5DR above the baseline threshold and no survey had U5DR around the emergency threshold of sub-Saharan Africa. This may reflect the fact that mortality is lower in areas where humanitarian agencies are operational, as their support to national programmes contributes to improving health. Furthermore, security conditions often

prevent agencies from accessing some of the severely affected zones. Finally, possible underestimation of mortality, due to inaccessibility of some affected areas mentioned above and survival bias owing to the possible disappearance of the entire households in crisis-affected areas [27], should not be ruled out. Overall, the lower than expected U5DR in our study raises questions regarding the accuracy of mortality thresholds being used, since substantial reduction in child mortality has been achieved in the MDG era [155]. Our findings therefore highlight the need to review and update the existing mortality thresholds [153], both the baseline and the emergency thresholds. Otherwise, considering mortality elevation from the baseline (if baseline is available) rather than comparing it with thresholds would also be more feasible.

Neither short- nor long-term droughts were associated with U5DR. This could be explained by the resilience capacity the country developed over time to deal with shocks related to drought and food shortage. First, the country adopted a national policy on disaster prevention and management in 1993 to reduce disaster risks and its potential consequences [156]. Weather forecasting and early warning systems have been strengthened, and relief assistance has become more predictable and timely [144]. Second, in 2005, Ethiopia launched a safety net program targeting chronically food-insecure households in famine-prone areas to provide a long-term solution for minimizing vulnerability to food insecurity. The program has been providing assistance in the form of food and cash transfer, building resilience to climate-related impacts, improving access to health, and enhancing risk financing mechanisms to protect assets from being eroded by recurrent shocks. The program benefits approximately 8 million people in rural areas annually [81, 157]. Third, road network development over the last decade has helped farmers easily access markets and relief providers reach remote villages. Fourth, the humanitarian response has become more efficient as it is based on early warning and assessment results during emergency [156].

The meta-regression shows that U5DR increases with the prevalence of GAM, echoing the well-documented fact that child wasting and mortality are directly associated [88, 141, 143, 147]. Malnutrition aggravates infectious diseases thereby increasing the risk of child mortality [158]. For example, in 2011, about 45% of all child deaths in the world (3.1 million child deaths) were attributable to undernutrition [88]; and in Ethiopia, this figure was 28% between 2004 and 2009 [133]. The effect is more apparent in countries going through humanitarian crises where the prevalence of malnutrition is twice that of low-income countries [23]. Despite the declining trend, the prevalence of acute malnutrition in crisis-affected areas in Ethiopia remains high, more than 10% [143, 150]. Therefore, unless continuous and targeted interventions are identified and implemented to improve child nutrition, a significant number of child deaths will occur due to acute malnutrition.

Food insecurity can be both a cause and a consequence of protracted crises and it increases child mortality by affecting food intake and increasing susceptibility to diseases [9]. Surprisingly, our result shows that areas with minimal food insecurity had higher U5DR than areas with stressed food insecurity. This finding contradicts the existing evidence [9, 148, 159], which indicates that higher food insecurity is directly associated with higher child mortality. One possible explanation is that areas with minimal food insecurity may not attract the attention of the government and aid agencies. Thereby, they will not receive the assistance which contributes to the improvement of child survival, such as health care, food assistance and other relief commodities. In this case, households may be forced to rely on their own livelihoods without external aid, thus there is a need to promote resilience within these households and communities. In a sense, these findings can be interpreted as a sign of the continued high reliance on aid by rural households. Nonetheless, this result needs to be interpreted with caution. First, we do not have full information on the possible contextual factors in the surveys (e.g., disease incidence, breastfeeding, access to health) which could elevate U5DR. Second, the reliability of the estimates might be affected as we have only four surveys conducted in minimal food-insecure areas. Thus, further research with a substantial number of surveys and considering the full range of contextual factors

is warranted.

While interpreting the results, the following limitations should be taken into consideration. First, retrospective mortality surveys are heavily affected by recall bias which may lead to underreporting of deaths or reporting of incorrect dates. Thus, to reduce the recall bias, we limited our study to surveys with a short recall period (3 months). Second, despite improvement in data quality assurance of mortality indicators in CE-DAT, and despite CE-DAT is a unique and detailed source of nutrition and mortality data for crisis-affected areas, the quality of survey implementation cannot be verified in-depth [68]. Had the raw data available, it would have been possible to detect bias, for example, through examining data for digit preference or the age distribution of deaths for systematic under-reporting. Future studies considering survey quality differences by assigning quality scores for each of the survey based on the CE-DAT quality checklist or other information in the report is recommended. Third, although CE-DAT strives to gather all nutrition and mortality surveys from humanitarian agencies, the possibility of missing some of the surveys is inevitable. However, we believe that this number is insignificant for Ethiopia, as the CE-DAT project has a strong data sharing agreement with the majority of the agencies operating in the country. Fourth, the majority of the small-scale surveys in CE-DAT do not have information on the underlying causes of child mortality, such as disease incidence, child care practices, water and sanitation coverage, and non-food interventions, which could account for part of the unexplained variation in the data. Despite these limitations, our meta-analysis sheds light on the limited literature surrounding the topic and stimulates debates for further exploration of the link between drought and child mortality in humanitarian emergencies.

4.5 Conclusions

In conclusion, the estimated pooled U5DR was below both the country's average and the baseline threshold for sub-Saharan Africa. This indicates the need to review and update the existing mortality thresholds. Exposure to both short-and long-term droughts was not associated with U5DR in Ethiopia. However, minimal food insecurity was associated with elevated U5DR, and hence these areas should not be overlooked by the intervention programs. Further, targeted interventions to improve the underlying causes of child malnutrition in crisis-affected areas are crucial, as acute malnutrition increases U5DR. Finally, our study recognizes the enormous progress made by the country in enhancing drought resilience.

Acknowledgments

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Chapter 5

Do Border Residents Suffer More From Malnutrition? Scrutinizing Nationally Representative Large-scale Survey Data

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This chapter is adapted from:
Tefera Darge Delbiso, Jose Manuel Rodriguez-Llanes, Chiara Altare, Bruno Masquelier, Debarati Guha-Sapir: "Health at the borders: Bayesian multilevel analysis of women's malnutrition determinants in Ethiopia." *Global Health Action 07/2016*; 9:30240.
http://dx.doi.org/10.3402/gha.v9.30204

Abstract

Background: *Women's malnutrition, particularly undernutrition, remains an important public health challenge in Ethiopia. Although various studies examined the levels and determinants of women's nutritional status, the influence of living near an international border on women's nutrition has not been investigated. Yet, Ethiopian borders are regularly affected by conflict and refugee flows, which might ultimately impact health. This study is therefore aimed to investigate the impact of living in close proximity to borders in the nutritional status of women in Ethiopia, while considering other important covariates.*

Methods: *Our analysis was based on the BMI of 6334 adult women aged 20–49 years, obtained from the 2011 EDHS. A Bayesian multilevel multinomial logistic regression analysis was used to capture the clustered structure of the data and the possible correlation that may exist within- and between-clusters.*

Results: *After controlling for potential confounders, women living in close proximity to borders (i.e., $\leq$ 100 km) in Ethiopia were 59% more likely to be underweight (posterior odds ratio (OR)=1.59; 95% credible interval (CrI): 1.32–1.90) than their counterparts living far from the borders. This result was robust to different choices of border delineation (i.e., $\leq$ 50 km, $\leq$ 75 km, $\leq$ 125 km and $\leq$ 150 km). Women in poor families, those with no access to improved toilet, residing in lowland areas, and being Muslim were independently associated with underweight. Whereas more wealth, higher education, older age, access to improved toilet, being married, and living in urban or lowlands were independently associated with overweight.*

Conclusions: *The problem of undernutrition among women in Ethiopia is most worrisome in the border areas. Targeted interventions to improve nutritional status in these areas, such as improved access to sanitation, economic and livelihood support, are recommended.*

5.1 Introduction

The nutritional status of women has important implications both for their own health and that of their children. Malnutrition increases women's susceptibility to diseases, slows recovery from illnesses and puts women at higher risk of pregnancy-related mortality. Children of undernourished women are more likely to be undernourished, which can lead to poorer cognitive development, shorter stature, and higher risk of morbidity and mortality. Malnutrition also hampers women's productivity and that of the society at large [86, 88, 160].

Women's undernutrition particularly remains a public health challenge in Ethiopia [71]. Comparative studies conducted in sub-Saharan Africa document the high prevalence of women's underweight in Ethiopia [161, 162]. When compared to 57 low- to middle-income countries, Ethiopian women have the lowest average BMI [163]. Various studies assessed the levels and identified the determinants of maternal malnutrition in Ethiopia using large scale datasets: some of which focused on smaller geographical areas [58, 164], others were representative of the entire country [161, 165].

Although health outcomes heavily depend on contextual factors, such as community based services and norms operating at community level [160], studies investigating women's nutritional status differentials in border areas are lacking. Border-related conflicts, commonly happening in the Horn of Africa [166–168], and the neglected and poorly developed infrastructure and services at the borders [167, 169] have the potential to undermine the socioeconomic and health-related wellbeing of the populations [170]. Moreover, influx of refugees fleeing crisis in neighboring countries are mainly hosted in camps located in the border areas, which might impact the livelihood and health of the hosting communities [170]. The assessment of health issues, such as nutritional status, is thus of particular relevance in countries like Ethiopia which is bordering conflict zones (Somali, South Sudan, Eritrea and Sudan), hosting a large population of refugees [13] and facing its own internal development challenges. This study is therefore aimed to assess the impact of living close to borders on the nutritional status of women in Ethiopia, while considering other important covariates.

5.2 Data and Methods

Our analysis was based on the 2011 EDHS dataset. The survey was conducted to provide information mainly on fertility, family planning, HIV/AIDS, maternal and child health, and nutrition indicators at national, regional, and urban and rural levels. A stratified two-stage cluster sampling design was used to select the sample households. First, each region was stratified into urban and rural areas. Then a sample of Enumeration Areas (EAs (clusters hereafter); sub-divisions of the smallest administrative unit in Ethiopia (*kebele*) based on the 2007 population and housing census) were selected independently in each stratum in two stages. In the first stage, 624 clusters (437 from rural areas and 187 from urban areas) were selected using PPS to the cluster size. In the second stage, households within the clusters were selected. However, in Somali region, 28 of the 65 clusters were not interviewed due to drought and security reasons. In total, 16,515 women of reproductive age (15-49 years) were selected from 596 clusters to form a representative sample of this age group. The data was then collected using a questionnaire which was adapted from the MEASURE DHS project. The Ministry of Health supervised the overall survey process, the Central Statistical Agency implemented the survey, and the ICF International provided technical support and funding for the project [71].

BMI was used to assess the nutritional status of women. The use of BMI cut-offs is not recommended for adolescents (15-19 years) due to the remarkable change in growth during this period [86]. Therefore, 3835 adolescents were excluded from the analysis. Further, 5714 pregnant and lactating women were excluded since BMI is not an appropriate indicator for this group either. We further removed 281 women due to missing weight or height and 6 women with flagged cases (implausible weight or height measurement) after revealing that the missing BMI values are randomly and proportionally distributed across the exposure variable. Moreover, 345 women without attribution of geographical location were excluded. Finally, 6334 adult women aged 20–49 years from 571 clusters were included in the analysis (Figure 5.1).

Outcome variable: The outcome variable was the women's nutritional status measured in BMI. For public health significance, we categorized

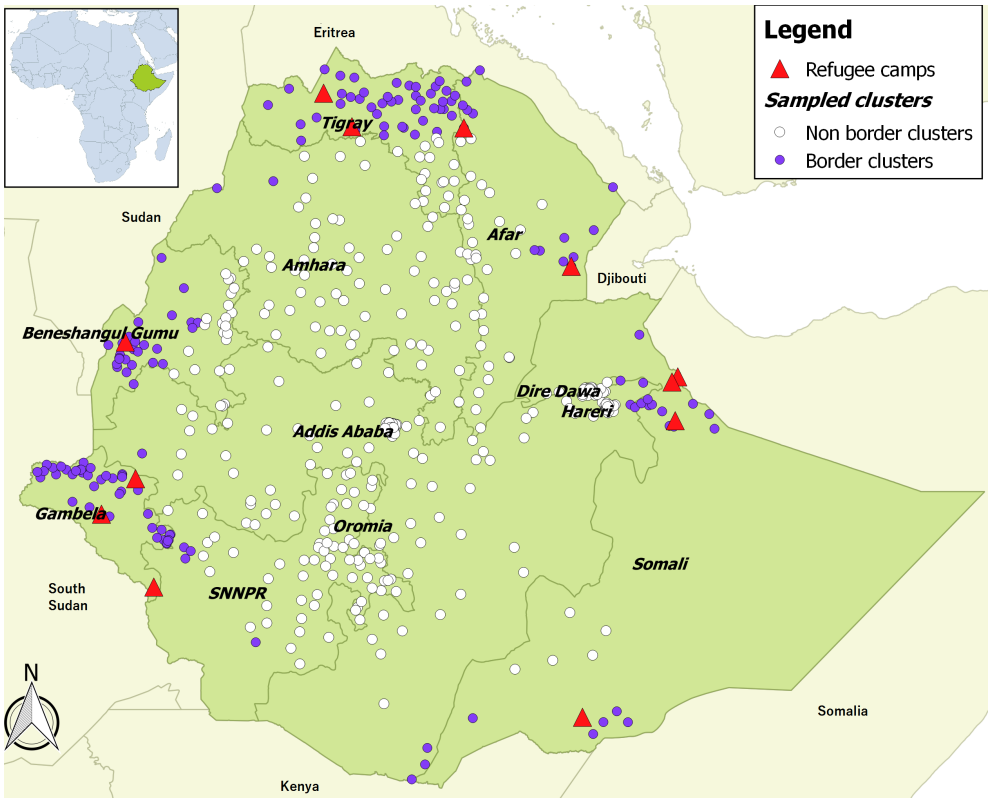

FIGURE 5.1: **Map of Ethiopia showing EDHS sampled clusters and refugee camps together with neighboring countries.**

the BMI according to the WHO recommended cut-offs distinguishing between – underweight (BMI $<$ 18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2) and overweight ($\geq$ 25.0 kg/m^2) [86].

Exposure variable: The exposure variable of the study is the residence status (border resident or not), measured by the nearest distance, in kilometers (km), from the borders to the sampled clusters. We used the GPS coordinates of the sampled clusters to measure the nearest distance to the border. Then, we dichotomized the distance into: border ($\leq$ 100 km) and non-border ($>$ 100 km), based on a previous study [171]. We also assessed the sensitivity of our results to the different delineation of borders: $\leq$ 50 km, $\leq$ 75 km, $\leq$ 125 km and $\leq$ 150 km.

Confounding variables: The selection of confounding variables was guided by previous studies [58, 161, 162, 164, 165]. These variables

are: woman's age (in full years); level of education (no education, primary, and secondary or above); marital status (never married, married or living together, and divorced or separated or widowed); religion (orthodox, protestant or catholic, and muslim or others); household headship status (woman headed or man headed); and place of residence (urban or rural). The wealth index – a composite measure of household's cumulative living standard based on ownership of selected assets, such as television, bicycle, materials used for housing construction, and types of water access and sanitation facilities – was provided in five quintiles in EDHS and we recoded it into three as: poor, middle, and rich. Toilet facility and source of drinking water were coded as improved or not improved based on the EDHS classification [71]. Further, three agro-ecological zones were defined based on the altitude data: lowland (< 1500m), midland (1500–2300m) and highland (> 2300m) above sea level, as altitude has a strong influence on climate and thereby agriculture and livelihood.

5.2.1 Statistical analysis

The EDHS data has a hierarchical structure, as women are grouped within clusters. This structure often yields data which are correlated and thus cannot be assumed independent. A multilevel approach adequately represents unexplained variability of nested structure, which is often difficult to represent in the single level approach [123]. Taking into account the hierarchical structure of the dataset and the possible correlation that may exist within- and between-clusters, we used a two-level random intercept multinomial logistic regression model (more detail in **Chapter 2 Section 2.3.3**).

In order to get unbiased estimates for the parameter in multinomial logistic regression, MCMC method was used as recommended by [172]. For the MCMC estimation, we used diffused prior distributions: normal priors with large variances (mean=0, variance=10^6) for regression parameters and inverse gamma ($10^{-3}, 10^{-3}$) for precision parameters. We then run the chain for 50,000 iterations with a burn-in length of 25,000 iterations to ensure convergence of the Markov chains. The convergence of Markov chain was assessed by visual inspection of the trace-

and autocorrelation-plots. Further, Bayesian Deviance Information Criterion (DIC) was used to evaluate the goodness-of-fit of the models [172].

Three models were fitted. Model 1 does not include any covariate; Model 2 include cluster level covariates (distance from the border, place of residence and agro-ecological zones); and Model 3 include variables in Model 2 and individual level covariates. We also conducted a sensitivity analysis to assess whether the different choice of distance from the border might have impacted the results. We used survey weight as provided in the EDHS, to ensure the representativeness of the sample characteristics.

Finally, we reported the posterior OR (it is also refered as relative risk ratio) and its 95% Bayesian CrI for each of the variables in the full model (Model 3). The statistical significance was judged based on the non-inclusion of 1.0 in the 95% CrI's. The statistical analysis was performed in STATA/IC 12.1 using runmlwin command, a program to run the MLwiN multilevel modeling software from within Stata [173]. The map was produced using QGIS [174].

5.2.2 Ethical approval

We used secondary data obtained in request from the DHS Program (https://dhsprogram.com/) with no information identifying the participants. The Ethiopian Health and Nutrition Research Institute Review Board, the National Research Ethics Review Committee, the Institutional Review Board of ICF International and the CDC have approved the EDHS. Informed and voluntary consent was obtained from the study participants.

5.3 Results

Table 5.1 presents the sample characteristics. The median women's BMI was 20.1 (interquartile range: 18.5–22.0 kg/m^2), with nearly 25% of them being underweight and 8% overweight. The average distance between a border and a cluster was 184.4 km (ranging from 0.2–449 km); 10% of the women lived near the borders (i.e., $\leq$ 100 km) (Figure 5.1).

The median age was 33.0 (interquartile range: 25.0–41.0 years). Over half of the women (56%) were not educated; 20% were never married; 31% were from poor family background; 30% were household heads; and 52% were orthodox religion followers. The proportion of women who had access to improved toilet facility and drinking water source were 22% and 59%, respectively. Most of the women (71%) were rural dwellers; over a tenth (12%) lived in lowlands (Table 5.1).

Table 5.2 presents results from the random intercept Bayesian multilevel multinomial logistic regression model (Model 3). After controlling for potential confounders, distance to a border was significantly associated with both underweight and overweight. The odds of being underweight were 59% higher among women living close to a border (OR=1.59; 95% CrI: 1.32–1.90) while the odds of overweight were 37% lower (OR=0.73; 95% CrI: 0.54–0.95) for similar comparisons. Table 5.3 shows the sensitivity analysis results for different choices of border definition. As we move closer to the borders, the odds of underweight increase (ranging from 35% higher odds for those who lived at 150 km distance from the border to 90% higher odds among those who lived within 50 km distance).

In addition, the odds of underweight were significantly higher among women from poor families (OR=1.41; 95% CrI: 1.15–1.70) compared to those from rich families; among lowland women (OR=1.32; 95% CrI: 1.09–1.60) compared to midland women; among muslim (OR=1.35; CrI: 1.09–1.65) compared to protestant; and among women who had no access to improved toilet facility (OR=1.28; 95% CrI: 1.05–1.52) (Table 5.2).

TABLE 5.1: **Sample characteristics of non-pregnant, non-lactating adult women aged 20–49 years in Ethiopia, 2011.**

Variables	n	% (95% CI)
BMI	**6334**	**20.1 (18.5, 22.0)****
Underweight		24.5 (22.9; 26.1)
Overweight		8.4 (7.4; 9.4)
Residence status	**6334**	
Border residents		10.3 (9.5; 11.2)
Age (years)	**6334**	**33.0 (25.0, 41.0)****
Level of education	**6334**	
No education		56.3 (54.4; 58.1)
Primary		28.4 (26.7; 30.1)
Secondary and above		15.3 (14.0; 16.7)
Marital status	**6334**	
Never in union		19.8 (18.4; 21.3)
Married/living together		61.0 (59.1; 62.8)
Others*		19.2 (17.8; 20.7)
Religion	**6331**	
Orthodox		51.9 (50.0; 53.7)
Protestant and Catholic		22.7 (21.1; 24.3)
Muslim and Others		25.4 (23.8; 27.1)
Household headship	**6334**	
Women headed		30.4 (28.7; 32.2)
Wealth index	**6334**	
Poor		31.4 (29.7; 33.1)
Middle		18.0 (16.6; 19.5)
Rich		50.6 (48.7; 52.5)
Drinking water source	**6152**	
Improved		59.3 (57.4; 61.1)
Toilet facility	**6146**	
Improved		21.6 (20.2; 23.1)
Place of residence	**6334**	
Rural		71.4 (69.6; 73.1)
Agro-ecological zone	**6334**	
Lowland		12.1 (11.1; 13.3)
Midland		54.4 (52.6; 56.2)
Highland		33.5 (31.8; 35.2)

CI – confidence interval; % (95% CI) are based on weighted sample; *Widowed/Divorced/Separated; ** Median (interquartile range); Catholic and other religion followers were 1.1% and 0.6%, respectively.

TABLE 5.2: **Posterior OR (95% CrI) from multilevel multinomial logistic regression model for associations between individual- and cluster-level covariates with women's nutritional status, EDHS 2011.**

Variables	Underweight vs. Normal	Overweight vs. Normal
Residence status		
Border residents	1.59 (1.32; 1.90)	0.73 (0.54; 0.95)
Non-border (Ref.)		
Age (years)	1.01 (1.00; 1.02)	1.07 (1.05; 1.08)
Level of education		
No education	1.05 (0.82; 1.33)	0.47 (0.35; 0.61)
Primary	0.92 (0.73; 1.14)	0.64 (0.51; 0.80)
Secondary+ (Ref.)		
Marital status		
Never in union	1.15 (0.92; 1.41)	0.60 (0.45; 0.78)
Married (Ref.)		
Others	0.87 (0.72; 1.06)	0.82 (0.62; 1.07)
Religion		
Orthodox	1.05 (0.85; 1.29)	0.97 (0.74; 1.26)
Muslim	1.35 (1.09; 1.65)	1.17 (0.86; 1.56)
Protestant (Ref.)		
Household headship		
Women headed	1.08 (0.92; 1.27)	0.93 (0.74; 1.14)
Men-headed (Ref.)		
Wealth index		
Poor	1.41 (1.15; 1.70)	0.46 (0.30; 0.67)
Middle	1.25 (1.00; 1.55)	0.36 (0.19; 0.59)
Rich (Ref.)		
Drinking water source		
Not improved	1.06 (0.90; 1.24)	0.84 (0.59; 1.17)
Improved (Ref.)		
Toilet facility		
Not improved	1.28 (1.05; 1.52)	0.61 (0.49; 0.75)
Improved (Ref.)		
Residence		
Urban	0.90 (0.70; 1.14)	3.18 (2.28; 4.33)
Rural (Ref.)		
Agro-ecological zone		
Lowland	1.32 (1.09; 1.60)	1.63 (1.27; 2.06)
Midland (Ref.)		
Highland	0.96 (0.78; 1.17)	1.10 (0.87; 1.38)

Ref.: Reference category; vs.: Versus

TABLE 5.3: **Sensitivity analysis: effect of different border definition on nutritional status, posterior OR (95% CrI) adjusted for the confounders.**

Variable	Underweight vs. Normal	Overweight vs. Normal
Residence status (vs. non-border)		
Border (≤ 50)	1.90 (1.56; 2.33)	0.73 (0.51; 1.05)
Border (≤ 75)	1.67 (1.39; 2.00)	0.72 (0.53; 0.97)
Border (≤ 100)	1.59 (1.32; 1.90)	0.73 (0.54; 0.95)
Border (≤ 125)	1.36 (1.13; 1.56)	0.86 (0.67; 1.08)
Border (≤ 150)	1.35 (1.15; 1.60)	0.97 (0.77; 1.23)

On the other hand, women who had no education (OR=0.47; 95% CrI: 0.35–0.61) or primary education (OR=0.64; 95% CrI: 0.51–0.80) were less likely to be overweight than women with secondary education or above. Similarly, women from poor families (OR=0.46; 95% CrI: 0.30–0.67) and middle class families (OR=0.36; 95% CrI: 0.19–0.59); who had no access to improved toilet facility (OR=0.61; 95% CrI: 0.49–0.75); and who were never married (OR=0.60; 95% CrI: 0.45–0.78) were less likely to be overweight. The odds of being overweight were much higher among urban women (OR=3.18; 95% CrI: 2.28–4.33); and women who lived in lowland areas (OR=1.63; 95% CrI: 1.27–2.06). Finally, one year increase in age was associated to 7% higher odds of being overweight (95% CrI: 5–8%) (Table 5.2).

The variances ($Var(u_1)$ and $Var(u_3)$) and covariance ($Cov(u_{13})$) estimates of the random effects parameters in Model 1 suggest that there is large variation in women's nutritional status between clusters. The inclusion of all covariates (Model 3) reduced the between-cluster variances substantially. Moreover, the reduction of Bayesian DIC from Model 1 to Model 3 suggests that the full model best fit the data (Table 5.4).

TABLE 5.4: **Cluster level random effects parameter estimates.**

Parameters	Model 1	Model 2	Model 3
$Var(u_1)$	1.25 (0.89; 1.69)	0.18 (0.10; 0.29)	0.07 (0.01; 0.15)
$Var(u_3)$	0.54 (0.40; 0.69)	0.31 (0.21; 0.43)	0.27 (0.16; 0.38)
$Cov(u_{13})$	-0.58 (-0.76; -0.42)	-0.22 (-0.30;-0.15)	-0.12 (-0.21; -0.06)
Bayesian DIC	10290.7	10104.4	9860.2

$Var(u_1)$ and $Var(u_3)$ are between-cluster variance between underweight vs. normal and overweight vs. normal, respectively; $Cov(u_{13})$ cluster-level variance.

5.4 Discussion

Border areas are prone to conflicts and refugee-related issues, but the available data and knowledge on health in general and women's nutrition in particular is scanty in these areas. Women's health, including an appropriate, sufficient and balanced nutrition, is central to their development and empowerment and has positive implication for the society as a whole. The fulfillment of women's nutritional needs is an issue of human development and not an isolated public health concern. However, our study reveals that about 25% of non-pregnant, non-lactating adult women in Ethiopia were underweight, while 8% were overweight. Such underweight prevalence is classified as a serious nutritional problem according to the WHO Expert committee on physical status [86]. Moreover, the odds of being underweight were 59% higher among women living in the border areas of the country.

Many factors can explain the border differentials. For example, Afar, Gambella, Somali and Benishangul-Gumuz regions in general and their peripheries in particular are poorly developed [72, 166]. On top of that, recurrent drought, land degradation, low level of livelihood diversification and inadequate coping strategies increased susceptibility to food crisis in Afar, Somali and Tigray regions [175, 176]. Overall, limited availability of health and other basic development infrastructures coupled with natural disasters, particularly droughts and floods in the borders [166–168] might contribute to the noticed high levels of underweight.

The border areas have been struggling with internal and cross-border violent conflicts: for example, instability has affected the regions of Afar [177], Somalia [44, 178], Gambella [179], Benishangul-Gumuz [44], and cross-regional clashes among Ethiopian pastoralists have also occurred [180]. These often precipitate humanitarian crisis to the existing fragile livelihood, limited infrastructure and services of the community [24] and might worsened women's health in the borders. Addressing internal and cross-border conflicts through strengthening indigenous systems and incorporating local perspectives for conflict resolution; and creating inclusive and strong government-community relations in conflict-prone borders could help improve the livelihood of the community.

Ethiopia has also hosted a large number of refugees escaping conflicts, political instability, inter-ethnic clashes and droughts in neighbouring countries [13]. The majority of refugees are settled in camps located in the border zones: Somalia refugees who fled insecurity and famine following the collapse of the central government in 1991 are mainly located in Somali region; Eritrean refugees seeking asylum after the Ethiopia-Eritrea war in 1998 are hosted in Tigray and Afar regions; South Sudanese refugees who fled inter-ethnic clashes since 1991 are hosted in Gambella region; and Sudanese refugees fleeing from the Blue Nile and Darfur conflicts are settled in Benishangul-Gumz region (Figure 5.1). Some refugees also live with host communities. Hosting refugees has both benefits and challenges for the communities that receive them [181–183]. Disease outbreaks, food scarcity, overburden of health facilities, security problems and environmental degradation are among the burdens refugees could bring to the already fragile hosting community [170, 181]. For instance, a study conducted in Tanzania documented price increase in non-aid food items in refugee hosting areas [184], while another study reported the increased incidence of malaria in refugee-receiving countries [185]. Thus, hosting refugees cannot be discarded as an additional contributor to the observed high prevalence of underweight in women residing near the borders. On the other hand, the presence of refugee camps can contribute to increased

economic activities, household consumption, and access to health services provided in the camp itself [181–183]. Therefore, integrating host communities in humanitarian interventions for refugees is crucial to increase acceptability and strengthen local response capacity. Further research to understand pathways through which refugees' presence affects women's health is needed.

Our results further depicted that lowland women were more likely to be underweight. In the lowland areas of Ethiopia, the communities are mainly pastoralist and semi-pastoralist [176]. Population growth, increased competition for scarce resources, loss of crop and livestock productivity due to natural disasters, and poor infrastructure development heightened vulnerability of pastorals livelihood [176, 177], which might have exacerbated the nutrition problem in the area. In addition, the low dietary diversity and calorie poor pastoralist diet [186], vector borne diseases like malaria and sleeping sickness in lowlands may directly or indirectly contribute to women's underweight [186, 187]. Pastoral communities would benefit from targeted interventions to improve access to water and health care for them and their livestock, diet diversification programs, and strengthening access to market and livestock trade.

It is well recognized that poverty affects an individual's health status by various channels, be it through household food security, health care utilization, access to sanitation facilities, and gender inequality [188]. Our study shows that women from poor families are more likely to be underweight, but less likely to be overweight. Our results are in line with similar studies conducted in Ethiopia and other developing countries [161, 164, 189–191], where poverty is associated with undernutrition. Lack of improved toilet facility is a proxy indicator for poor hygiene [192], and poor hygiene in turn increases the risk of diseases and can aggravate undernutrition. As expected, our results portrayed that women with no access to improved toilet facility had greater chances of being underweight. Muslim women were more likely to be underweight: one of the possible reasons might be the high fertility rate and shorter birth-interval of muslim women [193], which worsens maternal nutritional status [194].

We found that the odds of overweight increased with age, education, family wealth, having access to improved toilet facility, living in urban settings or lowlands. Studies conducted in Ethiopia and other developing countries corroborate our findings [164, 189, 191, 195], where these factors tend to be associated with overweight and obesity through reduced physical activity, increased sedentary lifestyle, and increased consumption of high calorie foods and animal products. Further exploration of our data revealed that those who had access to improved toilet facilities defines an urban profile, where overweight is more likely to occur. On the other hand, due to recurrent droughts, Ethiopian lowlands are primary recipients of large scale humanitarian aid [180], and relying on food assistance as the main source of food is a risk factor for overweight [196]. Further, Dire Dawa and part of Harari regions are located in the lowlands, which are predominantly urban areas where overweight tend to be higher. Finally, the lower odds of overweight among never married women could be because these women are more likely to be younger and less educated, which are protective factors against overweight. In sum, the problem of overweight should not be overlooked, given the well-acknowledged double burden of under- and over-nutrition currently faced developing countries [195].

Our study presents some limitations. First, BMI is influenced by body shape in population with heterogeneous body proportions (ratio of leg-length to torso-length) [86], the most likely case in Ethiopia given the ethnic diversity. Population with particular body shapes might also be those living in the border areas (e.g., Gambella women in the South Sudan border are taller than the average Ethiopian women). However, as EDHS dataset lacks sitting length to standardize the BMI, we used the BMI as provided in the survey. Second, since cluster level characteristics, such as community level poverty, education, access to toilet facility, were not collected in EDHS, we included only three cluster level covariates in our analysis (place of residence, agro-ecological zones and distance to the border). Third, the cross-sectional nature of the data only allows making inference on associations, but precludes establishing causal links. Finally, but importantly, our study

only addressed one health component, nutritional status in women 20–49 years of age. The prevalence of other diseases is also relevant, and other vulnerable groups, such as children, could also be affected by the border differentials. Moreover, this study can also be extended to other countries in similar situations, for example, DRC and Chad.

5.5 Conclusions

Women's malnutrition, particularly undernutrition, remains an important public health challenge in Ethiopia, which is not tackled adequately to date. The burden is particularly heavy among women who lived in the border zones. Targeted interventions to improve nutritional status in border zones, including improved access to sanitation and enhancing household wealth and livelihood, for example, through conditional cash transfer programs are recommended. Our results also acknowledge pockets of overweight particularly in urban and affluent families, which should not be overlooked. Finally, our study aims to foster the debate on the health of communities living near the borders by investigating both internal and external factors. In view of the growing trends in internal and cross-border insecurity both in Ethiopia and elsewhere in the region, this type of studies provides important insights into identifying vulnerable population groups and zones.

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Chapter 6

Discussion, Concluding Remarks and Future Directions

We conclude this thesis by summarizing the overall findings of the study and highlighting future directions. First, we discuss the potential of the existing health surveys in enhancing humanitarian decision-making. Second, we summarize the burden of malnutrition and mortality in drought, conflict and border-related settings in Ethiopia. Third, we discuss the implications of the existing policies and programs in mitigating the health impact of humanitarian emergencies in Ethiopia. Finally, we present the limitations of the study, recommend measures to be taken to improve the dearth of quality data for humanitarian decision-making, and set an agenda for future studies.

6.1 Maximizing the Decision-Making Potential of the Available National and Subnational Health Surveys in Humanitarian Settings

Evidence concerning malnutrition and mortality in a stable setting is widely available from surveillance and population-based household surveys. Nonetheless, such evidence are either limited [15, 67] or underused [68] in insecure settings. Given the scarcity of resources and the increasing number of humanitarian emergencies in the world [4, 12, 13], cost-effective and timely data becomes more important than ever before to improve humanitarian response and preparedness efforts.

The main data sources for health-related events are population- and health-service-based data sources. The former includes population censuses, household surveys, and surveillance; while the latter includes facility-based data on morbidity, mortality, service availability, service quality and utilization. To date, Ethiopia has conducted three national population and housing censuses (in 1984, 1994 and 2007) [72] and four DHSs (in 2000, 2005, 2011 and 2016) [84] to support the planning, implementation, monitoring and evaluation of population and health programs. Apart from that, a national family and fertility survey, malaria indicators surveys, behavioral surveillance surveys, the EPI surveys and nutrition surveys have been undertaken in different time periods. Despite the smaller geographical coverages and limited health indicators captured, six Health and Demographic Surveillance Systems (HDSS) and a mortality surveillance program are functioning under different universities across the country [197]. Moreover, a continuous effort has been put in place to install CRVS systems, yet a reliable nationwide system is far from reality. The health-service-based data, generated through routine recording and reporting of services delivered, are compiled by the Health Management Information Systems. Further, the community health information system collects data on demographic statistics, health service delivery and utilization based on the Health Extension Program (HEP; a community-based program providing primary-level preventive services for households) packages [198].

The aforementioned data, however, are often collected in stable settings at the national level. Therefore, they often ignore pockets in humanitarian crisis situations because of inaccessibility due to insecurity and/or disasters. For example, in the 2011 EDHS, 28 of the 65 selected enumeration areas in Somali region were not listed nor interviewed due to drought and security concerns [71]; the 2005 EDHS did not cover five clusters due to inaccessibility [85]; the 2007 population and housing census excluded eight *kebeles* in Afar region, bordering Eritrea, for security reasons [72].

Despite calls for more data in humanitarian settings, applying advanced and complex survey analysis methods in the available household surveys could still provide evidence to identify vulnerable groups and suggest potential interventions. In this regard, an unexploited wealth of well-designed, high quality and easily available household surveys, such as the DHS, provides a solution in data dire situations. Using the DHS data, for example, Akresh and colleagues assessed the effect of the 1998–2000 Eritrean–Ethiopian war on child health [50], and the 1967–70 Nigerian civil war on adult stature four decades after the war [199]; Delbiso and colleagues investigated the impact of living near international borders on women's nutritional status in Ethiopia [125]; Tatah and colleagues examined the impact of refugees on local health systems in Cameroon [200]; Gaire and colleagues investigated the impact of natural disasters on child stunting in Nepal [201]. Indeed, these household surveys often suffer from limited geographical coverage and poor data quality in areas affected by humanitarian crises, since accessibility becomes difficult.

Various humanitarian organizations engaged in relief and recovery activities in fragile countries, including Ethiopia, are actively collecting data to improve their operations (i.e., to identify and confirm hotspots, to quantify resource requirement and coverage, to monitor and evaluate programs, to generate baseline information, and for intervention and advocacy purposes). Aggregate analysis of these data is shown to be a cost-effective alternative for humanitarian decision-making [68, 73]. For example, Degomme and Guha-Sapir [27] documented conflict dynamics and causes of death in Darfur; Mason et al. [202] assessed

trends in malnutrition and mortality in population affected by displacement in the Horn of Africa; Nielsen et al. [203] analyzed trends in malnutrition and mortality in Darfur; Rowhani et al. [127] examined the impact of inter-annual variability in ecosystems on malnutrition and armed conflicts in East Africa; Guha-Sapir and Ratnayake [204] provided evidence on the consequence of the ongoing civil conflicts in public health indicators in Somalia; all based on aggregated data from small-scale surveys. The small-scale surveys are indispensable to reduce cost, save time and speed the humanitarian preparedness and response efforts.

Recognizing the potential of humanitarian organizations data to improve data-driven humanitarian decision-making, the CE-DAT initiative pioneered a program in 2003 to compile health indicators data in a centralized system. The CE-DAT is based on small-scale surveys from populations affected by humanitarian emergencies [68, 73]. Similarly, the ENCU of Ethiopia launched a nutrition database in 2005 to store survey results from organizations conducting emergency nutrition assessments in the country [135]. Despite the availability of many small-scale surveys in CE-DAT and ENCU, rigorous analysis of such datasets is lacking in Ethiopia. Furthermore, lack of detailed investigation of the existing nationally representative household surveys (e.g., the EDHS) undervalues the potential usage of the datasets in identifying hotspots and crisis-affected populations, and their public health needs.

Having identified the research gaps and convinced on the importance of thorough investigation of the existing national and subnational health surveys for evidence-base in areas otherwise inaccessible, we prompted to undertake this research project. With these backdrops, we applied advanced epidemiological methods, including meta-analysis and multilevel modeling in a Bayesian framework, to identify crisis-prone segments of the population and investigate their public health burden. In particular, we estimated the burden of acute malnutrition among children 6–59-month-old (**Chapter 3**) and the U5DR (**Chapter 4**), and then identified their risk factors (**Chapter 3** and **Chapter 4**) using small-scale operational survey data from crisis-affected

areas in Ethiopia. Further, we assessed the burden of women's malnutrition and its determinants in poverty-stricken and crisis-prone border zones in Ethiopia (**Chapter 5**) using nationally representative large-scale survey data, the 2011 EDHS.

6.1.1 The public health impact of droughts and conflicts in Ethiopia

Over the last decades, drought mitigation efforts have greatly improved. However, apart from sketchy and scattered evidence, rigorous synthesis of empirical data on the health impacts of climate change in general [205] and droughts in particular [66, 145] are lacking in Ethiopia and elsewhere in the world. This, in turn, creates an evidence vacuum to evaluate the impact of the ongoing programs in preventing and reducing drought risks on public health and to guide effective adaptation strategies. Thus, in this study, we attempted to fill this evidence gap.

According to our findings, **exposure to moderate drought was associated with elevated child undernutrition (Chapter 3); however, both short- and long-term drought exposures had no association with U5DR in crisis-affected areas in Ethiopia (Chapter 4)**. Several measures have been taken to deal with the brutal impact of recurrent and severe droughts in Ethiopia. For example, as a lasting solution to the 1984–85 famine, resettlement of the population from drought-prone areas in the north to the fertile areas in the south was attempted in the aftermath of the famine. In addition, villagization, settling the population in planned villages, was carried out to improve access to social services [34]. Subsequently, famine early warning systems were established to provide information on food security for communities in drought-prone areas. Different agencies, such as the Relief and Rehabilitation Commission (Commission for Disaster Prevention and Preparedness as of 1995), were established to coordinate drought response and preparedness activities, assess the needs and mobilize resources the soonest possible [36]. Moreover, development programs, such as the PSNP, have rolled out to minimize drought impacts through the provision of long-term assistance for drought-prone areas [157]. Overall, the country implemented numerous policies and strategies to mitigate

the catastrophic effects of drought (see more detail in the next section); most notably, the Food Security Program (FSP), the National Policy on Disaster Risk Management, the Pastoral Development Policy and Strategy Framework, and the Climate Resilient Green Economy [39, 206].

Despite the promising outcomes of the existing drought mitigation programs, recurrent droughts are still posing unprecedented impacts. For example, the 2015–16 El Niño induced-droughts caused a substantial drop in agricultural yield (up to 80% drop in some areas) [8, 60]. Although moderate droughts contribute to poor nutrition, its effect seems underestimated. As discussed in **Chapter 3**, the existing early warning systems and humanitarian responses are towards severe drought-prone areas, giving less or no emphasis to the possible impacts of moderate droughts.

The impact of violent conflicts on malnutrition and mortality is well documented [9, 12, 26, 28, 29, 50, 124, 141, 142, 199, 207]. However, although the impact of conflict is most severe in the specific areas where it happens, all the aforecited studies did not consider a refined spatial resolution to accurately measure conflict impact. Rather, they considered either the whole countries or regions as conflict-affected. Unarguably, such generalization could bias the real health impact of conflict events, given the localized impact of many violent conflicts. With this limitation in mind, we matched the conflict events data at the lower administrative units with the nutrition data at the same spatial resolution to accurately measure its impact. However, **we failed to find a plausible association between violent conflicts and child undernutrition in Ethiopia (Chapter 3)**, a finding that contradicts most studies [29, 50, 199] but is in line with others [127, 143]. As discussed before, in the last two decades, Ethiopia in general was politically stable and did not experience severe or intense conflicts. Most of the conflict events happened in the period were short-lived and had less causality, and hence might not have had a substantial impact on nutrition.

Despite the relative peace since the end of the 1998–2000 Eritrea-Ethiopia war, and despite its pivotal role in the regional peace and security, Ethiopia has been ravaged by internal conflicts in the recent

years. Conflicts resulting from disputes over administrative boundaries, grievances caused by systematic discrimination in the attribution of resources and political power, identity and political marginalization, high unemployment, poor governance, and corruption are becoming more prevalent and deadly [25, 43–45, 47, 208]. As of 2015, for example, unrest has been swept throughout the country. Anti-government protests driven by accumulated grievances from different groups coupled with ethnic and cross-border clashes are threatening the country's stability and the overall livelihood. The protests have been disrupting the normal day-to-day activities, affecting the social and economic service provisions, terrorizing the whole country, and taking a heavy toll on the economy [47]. Such widespread protests create unprecedented instability and eventually impact the health outcomes unless they are addressed properly.

6.1.2 The burden of women's malnutrition in crisis-prone border zones in Ethiopia

Border communities are regularly confronted with numerous health-related matters, but the available data and knowledge are scanty [209]. The increasing cross-border movements of people following the growing economic, political and social integrations along with the lack of health or immunization screening for border crossers in many countries bring new challenges to deal with communicable diseases, such as malaria, HIV/AIDS, and tuberculosis [209, 210]. Cross-border violence conflicts, criminalities, and substance abuses are also reported to be prevalent in the border areas and contribute to security challenges for the communities [168, 179, 209]. Border communities are often neglected and have inequitable access to resources, health and other services [167, 169, 209]. Furthermore, refugees fleeing humanitarian crises in the neighboring countries are mainly hosted in border zones and therefore overburden the already scarce livelihoods and services of the communities thereby worsening their health and nutritional status [170, 181, 209]. Overall, the growing cross-border insecurity along with the aforesaid problems in Ethiopia and elsewhere in the region is a matter of concern and leads to heightened vulnerability to specific

population groups.

In line with this discussion, **our study confirms that women's malnutrition in Ethiopia is particularly pervasive among border communities (Chapter 5)**. As already discussed, despite its own internal political and security challenges, Ethiopia is dealing with the residual effect of conflict-torn neighbouring countries – Somalia, South Sudan, Sudan and Eritrea. A large numbers of people escaping the humanitarian situations in those countries are sheltered in Ethiopia as refugees. These refugees are predominantly hosted in camps located in the least developed and conflict-ridden border zones of the country, which would pose an additional burden to the hosting communities and would contribute to the observed malnutrition problems. Nonetheless, we do not rule out the positive contribution of hosting refugees to the local populations by stimulating the local economies through humanitarian assistance flows, infrastructure development, employment opportunities, encouraging new production through price changes in agriculture and livestock markets [181, 183] and improving access to health care [181, 182, 200].

6.2 Implications of the Existing Policies and Programs in Mitigating the Burden of Malnutrition and Mortality in Humanitarian Emergencies in Ethiopia

We found that **the burden of child undernutrition in crisis-affected areas of Ethiopia is declining (Chapter 3) and the burden of U5DR is lower than both the emergency and the baseline thresholds for sub-Saharan Africa (Chapter 4)**. The observed reductions in both child undernutrition and mortality can be considered as the legacy of different development programs undertaken to reduce poverty and improve livelihoods in the country. With great ambition to eradicate poverty and achieve sustainable development, the country implemented different policies and strategies focusing on agricultural development. In 1991, the Ethiopian government launched its flagship policy, the Agricultural Development Led Industrialization (ADLI), with the objective to alleviate food security and agricultural productivity challenges. Subsequently, the Sustainable Development and Poverty Reduction Program (SDPRP) (2002/03–2004/05), the Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) (2005/06–2009/10) and the Growth and Transformation Plan (GTP1) (2010/11–2014/15) have been implemented. The programs paid off substantially; crop production has increased, infrastructure development has boomed, and the country witnessed rapid economic growth and poverty reduction [81].

Following the 1973–74 and 1984–85 famines, food security become the main focus of the successive governments' policy in Ethiopia [38]. Launched in 1996 and revised in 2002, the FSP has been enabling chronically food-insecure people to attain long-term food security. The different components of the FSP, including the PSNP, the Household Asset Building (HAB) and Voluntary Resettlement Programs (VRP) have improved food security through cash transfer or food-for-work, creating sustainable household and community assets, preventing asset depletion and improving access to fertile lands [81, 206], despite some reported weaknesses related to the complexity of food security itself and inadequate planning [211]. The PSNP, one of the largest social

protection programs in Africa, has been supporting more than 7 million rural food-insecure households annually [81]. The program has improved household food security [157, 212] and reduced short-term acute malnutrition [213].

Emphasizing the needs of the less-privileged rural populations and acknowledging the fundamental components of health (physical, mental and social well-being), the Ethiopian government launched the first comprehensive Health Policy in 1993 [214]. Following the policy, a successive twenty-year Health Sector Development Programs (HSDPs), in four phases (from 1996–97 to 2014–15), have been implemented to expand access and coverage of health services so as to improve health outcomes. Different strategies and programs have been developed and implemented under HSDPs: HEP, child survival strategy, reproductive health strategy, national nutrition program, and national hygiene and sanitation strategy [83] are notable examples.

The HEP has been in place since 2003 with the aim to improve access and utilization of preventive and basic curative health services to all Ethiopians, particularly women and children in the rural areas. The four major areas of the HEP – disease prevention and control, family health services, hygiene and environmental sanitation, and health education – are closely linked to child survival strategies. Particularly, programs, such as immunization, oral rehydration therapy, child health and nutrition education, and distribution of vitamin A, bed nets, anti-malaria and deworming, are included to improve child health [215]. As a result, immunization for measles and diphtheria-pertussis-tetanus (DPT3), the two big contributors to child mortality, for example, rose from 37% and 42% in 2001 to 87% and 92% in 2014, respectively [81]; insecticide-treated bed net usage among children and women have improved [216]; access to safe drinking water and sanitation practices have expanded [84, 217]. Overall, the country's health sector has shown impressive progress: physical access to health services expanded, health service delivery and utilization improved, and hence health outcomes enhanced [81, 83].

Nutrition has been included as a 'cross-cutting issue' in all of the four HSDPs [218]. In 2008, the National Nutrition Strategy (NNS) was launched with the aim to ensure all Ethiopians secure adequate and sustainable nutrition. Subsequently, the National Nutrition Program (NNP) was introduced in 2013 to improve the coordination of nutrition approaches and programs [198, 219]. Other health and nutrition programs, such as Community Management of Acute Malnutrition (CMAM), Community-based Nutrition Programe, Integrated Community Case Management (ICCM), and Enhanced Outreach Strategy (EOS)/ Targeted Supplementary Food (TSF) programe, are in place [218].

As discussed in **Chapter 3**, over the last decade, the country showed considerable economic growth and therfore the share of population living below the poverty line declined sharply [3], and the prevalence of extreme hunger decreased substantially – the MDG target of reducing hunger by half between 1990 and 2015 has achieved [9]. Primary healthcare coverage expanded and health outcomes improved; notably, the MDG target of reducing child mortality has met three years ahead of the 2015 deadline [10, 81, 215]. Most importantly, the majority of the programs prioritizes vulnerable population groups and crisis-prone areas. All these can explain the observed reduction in child undernutrition and mortality in our study.

Despite all the efforts and considerable progress made so far, malnutrition is still a widespread and deep-rooted problem in Ethiopia in general [71, 84, 85] and in crisis-affected areas in particular [143, 150]. The burden of both child undernutrition (**Chapter 3**) and women's undernutrition (**Chapter 5**) in our study shows a serious nutrition crisis according to the WHO classification [86]. This could be explained by the rampant poverty and recurrent food insecurity crisis still prevalent in the country. The food security indicators – diet quantity, diet quality, diet adequacy, and wealth and poverty – are still inadequate. According to the Comprehensive Food Security and Vulnerability Analysis of Ethiopia, 40% of Ethiopians consume inadequate quantity (food energy deficient), 50% consume highly unvaried diet (over 75% of the total calories from starchy staples only) and 30% consume poor quality diet

(three or fewer food groups). Furthermore, 28% of households spend less on food than required (they are below the food poverty line), and 12% spend more than 65% of their expenditure on food (the higher expenditure on food indicates the more economic vulnerability) [220]. The food insecurity crisis is deepening with land degradation, population pressure, small land holdings, backward farm technology, limited-off farm employment, and poor household asset accumulations, among others. In addition to that, shocks, including seasonal droughts, floods, food price inflations and food shortages, deteriorate livelihoods and force households to limit their meal portions or frequencies, shift to less expensive and less desirable food, rely on external aid, sell animals and borrow money [28, 220].

There is also a huge variation in nutrition indicators across regions and livelihood zones. **The prevalence of child undernutrition was the highest in Somali and Afar regions (Chapter 3); and lowland women were more likely to be underweight (Chapter 5)**. These findings can be interpreted in relation to the uneven development and vulnerability to different shocks across the regions and livelihood zones, which could directly or indirectly influence nutritional status as discussed in **Chapter 3** and **Chapter 5**. Additionally, despite a significant progress in reducing poverty, the number of poor Ethiopians has increased in seven of the eleven administrative regions between 1995–96 and 2010–11. Particularly, the increase was more than 50% in Somali and Afar regions; food poverty (the inability of individuals and households to obtain adequate and nutritious diet for healthy and active life) has also increased in these regions [220]. The lowlands of Afar and Somali regions are home for the majority of Ethiopian pastoralists and are highly vulnerable to shocks, including livestock deaths, droughts and malaria [187, 220], which contributes to poor nutrition. Moreover, some of the nutrition programs in these regions have either low in coverage (e.g., CMAM) or integrated lately to the HEP (e.g., EOS and ICCM) limiting some of the *woreda's* benefit from the programs [218].

6.3 Limitations and Concluding Remarks

6.3.1 Limitations

The CE-DAT initiative collects nutrition and mortality surveys from humanitarian agencies, but the possibility of missing some of the surveys due to data sharing or publication biases is inevitable. Nevertheless, we believe that these limitations are not severe in our study for the following two main reasons. First, the CE-DAT project has a strong data sharing agreement with humanitarian partners operating in Ethiopia, and hence the data sharing process is effective. Second, we added more surveys from other similar databases compiling emergency nutrition assessment data, such as the ENCU database, and also through online search to increase the completeness.

Checking the quality of small-scale surveys is challenging. However, to a large extent, this limitation was dealt with in the different stages of the survey process and data analysis. First, most of the surveys used the standardized nutrition survey methodology, SMART, accompanied by ENA software for sample size calculation, quality checks, standardization of anthropometric measurements, and report generation with automatic analysis. Second, for most of the surveys, the field operation was closely followed by the ENCU of Ethiopia, and the CE-DAT team undertook the entire survey validation process before releasing the data. Third, the use of Bayesian methods in the analysis allows incorporation of uncertainty in all parameters and borrow information from other surveys, and therefore lessens the potential effects of quality difference across the surveys. Yet, future studies could benefit from introducing survey quality weight in the analysis to control the quality differences across the surveys.

Contextual information of malnutrition (Figure 1.5) are not always collected or have poor quality in some of the surveys. Examples include, disease incidence, child care practices, water and sanitation conditions, coping strategies, and non-food interventions, are among the variables either not collected or poorly captured in some of the surveys. This could limit the study's ability to fully identify the causes of malnutrition, but still provides insight into the impact of humanitarian

emergencies on nutrition.

There is no single index to adequately characterize drought conditions for every place and time period. The selection of drought indices therefore depends on the types of drought, regions of concern, objectives and available information. The drought index we used, the SPEI, is a model based index that includes only climatological information without assumptions about the characteristics of the underlying state [101]. However, we acknowledge that the underlying factors, such as the socioeconomic conditions, infrastructure development and stability, affect drought impacts, yet SPEI is one of the refined index to identify the spatiotemporal extent of drought and its intensity.

The conflict event databases, both ACLED and UCDP, are predominantly based on media and humanitarian organizations reports, which could be prone to reporting bias for political or other reasons. We tried to minimize this bias by combining the two databases and considering only the occurrence of conflicts, as data on the impact of conflicts (e.g., no. of deaths) are more likely suffer from reporting biases. More limitations are discussed in each of the three published papers (**Chapter 3**, **Chapter 4** and **Chapter 5**).

6.3.2 Concluding Remarks

Humanitarian emergencies, mainly recurrent droughts and violent conflicts, are widely prevalent in Ethiopia, but comprehensive analysis of their impact on nutrition and mortality is limited. This is either due to the lack of nationally representative data in crisis-affected populations or the non-generalizability of subnational nutrition and mortality surveys conducted in such populations. Consequently, humanitarian decisions and advocacies are often based on anecdotal information or non-representative data with limited geographical coverage. The overall aim of this research was therefore to investigate the burden of malnutrition and mortality, and to identify its causes in humanitarian settings. Recognizing the data challenges, we applied advanced epidemiological methods in the available national and subnational population-based

household surveys. By doing so, we provided evidence to guide effective humanitarian response and preparedness actions.

The following main points are worth mentioning:

- Despite an overall declining trend, child undernutrition persists in humanitarian settings in Ethiopia; and disparities across administrative regions are evident. As the causes of malnutrition are complex and interlinked (Figure 1.5), multisectoral efforts are needed to address the problems. Strengthening the implementation of the existing policies, and continuous monitoring, evaluation and updating of the programs are crucial to further improve the nutrition situation of populations in humanitarian settings. Broadening the economy base and enhancing the health system by prioritizing the underdeveloped regions (particularly, Afar and Somali) is vital to alleviate the regional disparities. Overall, strong investment and consistent follow-up of the implementation of nutrition sensitive interventions and programs, such as agriculture, social safety nets, child development and education, are perhaps necessary to improve child nutrition in the country in general and in humanitarian settings in particular.

- We found a higher prevalence of child undernutrition in moderate drought-affected areas. Similarly, we identified elevated child mortality in minimal food-insecure areas. In light of these findings, we recommend to re-consider the so called "better-off" areas while designing development programs and child survival interventions. In this regard, for example, expanding the PSNP (which is currently targeting households in the most food-insecure areas based on the history of emergency food needs) to moderate drought areas and minimal food-insecure areas would improve food security and therefore enhance child survival.

- We learned that the burden of women's malnutrition was the highest in the border zones. Interventions targeting the border communities, including improved sanitation and household economies, for example, through conditional cash transfer, are essential to enhance their livelihoods and eventually women's nutritional status. Moreover, engaging the local residences in the humanitarian

response operations and sharing and/or integrating services provided to refugees with the local communities is crucial to assure mutual benefits and to facilitate a swift integration of refugees within the local communities. In this regard, we recognize the coordinated efforts of the Ethiopian government and other stakeholder's, led by the Administration for Refugee and Returnee Affairs, to improve the lives of refugees through different activities, including access to education and job opportunities.

- Although we found no association between conflict and child undernutrition, and between drought and child mortality, the mitigation efforts should not downplay the adverse health effects of these events. Much progress has been achieved in enhancing early warning systems and improving the effectiveness of humanitarian aid over the last decade. As a result, the burden of child mortality fell below both the emergency and baseline mortality thresholds of sub-Saharan Africa. In view of the growing trends in internal conflicts and protests, however, the country must understand the root causes and address them in a concrete way and most importantly at an early stage in the process of breakdown. At the last, but not the least, we hope that this study will stimulate the efficient use of publicly available databases for informed decision-making in humanitarian settings, but also in stable settings too.

6.4 Future Directions

6.4.1 Future directions to improve the coverage and quality of data for humanitarian decision-making

Encourage countries to develop their own databases to compile subnational surveys. The CE-DAT is a unique database determined to gather small-scale nutrition and mortality surveys from crisis-affected populations in the world, but the data sharing is mainly limited to either humanitarian agencies who signed a memorandum of understanding with CRED or agencies publishing their surveys online. This could undermine the representativeness of the surveys when surveys from certain parts of the country or from certain organizations are not captured. Decentralizing the system to the countries and providing technical support to the country initiatives would improve the coverage and minimize the data sharing bias. Furthermore, promoting the use of small-scale operational surveys for policy ingredients and academic purposes would increase the return on investment of the surveys. Developing a web platform where all agencies conducting surveys could upload their reports and raw data would also facilitate the data sharing process. Apart from nutrition and mortality surveys, this approach can also be customized to other health and livelihood indicator studies, such as food security and reproductive health surveys.

Collect useful contextual information and causes of death data. Data on the contextual factors, such as food security, infant and young child feeding practices, disease incidence, climate variability and land tenure, are important to get the full picture of the severity of the current situation, future trends, program needs and causes of malnutrition and mortality in humanitarian settings. However, the majority of small-scale surveys lack contextual information; for example, among the small-scale nutrition surveys conducted in Ethiopia between January 2003 and December 2008, only half of them collected contextual information [221]. Moreover, the burden of disease and cause of death data are crucial to identify high-risk areas, and to monitor and evaluate the effectiveness of public health programs, but such information is lacking or not detailed enough in the small-scale mortality surveys.

Collect or integrate spatial covariates to measure humanitarian emergencies in national population-based household surveys. Even though the DHS is a well-designed and nationally representative survey, it lacks indicators to measure humanitarian crises and its impacts. Based on the studies we have conducted using the DHS datasets [125, 200, 201], we recommend the DHS program to collect or integrate disaster exposure and violent conflict data in their datasets. In this regard, we shared our findings with the DHS program directly. They noted our recommendations and sent out a survey asking data users to suggest potential spatial covariates, such as rainfall, temperature, population density and access to roads, they would like to be linked to the final DHS datasets. We are hoping that the future DHS datasets would allow users to include spatial data in their analysis to help assess the public health impact of humanitarian emergencies and therefore better target interventions.

6.4.2 Future directions for research

Explore the public health impact of hosting refugees in Ethiopia. With the growing number of refugees around the world, the debate over the impact of hosting refugees on the hosting population's livelihood and health service utilization becomes the top agenda of hosting countries. Albeit Ethiopia is among the top five refugee-hosting countries in the world in 2015 [13], such evidence is non-existing. Therefore, in-depth studies are warranted to specifically figure out both the pros and cons of hosting refugees in the local communities in the Ethiopian context. Furthermore, such evidence would lay a foundation to understand the cross-border health issues and therefore would contribute to Africa's Regional Integration efforts.

Investigate the public health impact of droughts at the national level. Our studies based on the CE-DAT surveys (i.e., the drought, malnutrition, and mortality association studies) can also be extended to stable settings using the nationally representative EDHS data. The EDHS provides the raw data on nutrition and mortality indicators geocoded at the cluster level. This data can be combined with drought indicators at the same level and would provide more representative and robust

evidence on the public health impact of droughts at the national level.

Establish the risk factors for malnutrition and mortality in humanitarian emergencies according to the conceptual framework of malnutrition. Both the national and subnational population-based household surveys we used lack information on some of the contextual factors depicted in the framework (Figure 1.5). This, in turn, constrains our study's ability to fully understand the determinants of poor maternal and child nutritional status in humanitarian emergencies. Thus, further studies considering a wide range of covariates are warranted to enable us to identify the risk factors and therefore strengthen data-driven response and preparedness actions.

Apply the findings as a *prior* information for future studies. As our findings are based on a large number of small-scale surveys, they can be used as a credible source of *prior* information for future studies applying Bayesian methods.

Review and update the existing baseline and emergency mortality thresholds. Over the last decades, a substantial progress has been made in reducing child mortality, both in stable and fragile settings around the world [6]. The emergency thresholds may need to be reviewed and updated accordingly, as the current thresholds dated back to 1997 when the Sphere project (Humanitarian Charter and Minimum Standard in Humanitarian Response [153]) was launched. Based on our findings [222], we provided feedback (when they were circulating the draft version for feedback) to update the thresholds in the 2018 edition of the Sphere project handbook (under revision) and looking forward to the latest version updated.

Bibliography

[1] Inter-Agency Standing Committee. “Definition of Complex Emergencies”. In: (1994). URL: https://interagencystandingcommittee.org/content/definition-complex-emergency.

[2] WHO. *Environmental health in emergencies and disasters: a practical guide*. Ed. by Benjamin Wisner and Adams John. WHO, 2002.

[3] The World Bank. *World Development Indicators 2017*. Tech. rep. Washington DC: The World Bank, 2017.

[4] FAO et al. *The State of Food Security and Nutrition in the World 2017: Building Resilience for Peace and Food Security*. Tech. rep. Rome: FAO, 2017. URL: http://www.fao.org/3/a-I7695e.pdf.

[5] UNICEF, WHO, and World Bank Group. *Levels and Trends in Child Malnutrition - UNICEF / WHO / World Bank Group Joint Child Malnutrition Estimates*. Tech. rep. New York: UNICEF, WHO and World Bank Group, 2017.

[6] UN IGME. *Levels & Trends in Child Mortality: Report 2017, Estimates Developed by the UN Inter-agency Group for Child Mortality Estimation*. Tech. rep. New York: UNICEF, WHO, The World Bank and UN-DESA Population Division, 2017.

[7] WHO. *Trends in maternal mortality 1990 to 2015: Estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division*. Tech. rep. Geneva: WHO, 2015. URL: http://www.who.int/reproductivehealth/publications/monitoring/maternal-mortality-2015/en/.

[8] FSIN Food Security Information Network. *Global Report on Food Crises 2018*. Tech. rep. FSIN Food Security Information Network, 2018.

[9] FAO, IFAD, and WFP. *The State of Food Insecurity in the World 2015. Meeting the 2015 international hunger targets: taking stock of uneven progress*. Tech. rep. Rome: FAO, 2015. URL: http://www.fao.org/3/a-i4646e.pdf.

[10] Danzhen You et al. “Global, regional, and national levels and trends in under-5 mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Inter-agency Group for Child Mortality Estimation”. In: *The Lancet* 386 (2015), pp. 2275–2286. DOI: 10.1016/S0140-6736(15)00120-8.

[11] WHO. *WHO says address protracted emergencies to achieve Sustainable Development Goals*. 2016. (Visited on 04/03/2017).

[12] Ali H Mokdad et al. “Health in times of uncertainty in the eastern Mediterranean region, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013”. In: *Lancet Global Health* 4 (2016), e704–13. DOI: 10.1016/S2214-109X(16)30168-1.

[13] UNHCR. *Global Trends: Forced displacment in 2015*. Tech. rep. UNHCR, 2016.

[14] UN. “Transforming our world: the 2030 Agenda for Sustainable Development”. 2015. URL: https://sustainabledevelopment.un.org/content/documents/21252030AgendaforSustainableDevelopmentweb.pdf.

[15] Jennifer Leaning and Debarati Guha-Sapir. “Natural Disasters, Armed Conflict, and Public Health”. In: *New England Journal of Medicine* 369 (2013), pp. 1836–1842. ISSN: 0028-4793. DOI: 10.1056/NEJMra1109877.

[16] CRED. *The human cost of natural disasters 2015: a global perspective*. Tech. rep. Brussels: CRED, 2015. URL: http://cred.be/publications.

[17] Debarati Guha-Sapir, Regina Below, and Philippe Hoyois. *EM-DAT: The CRED/OFDA International Disaster Database*. URL: http://www.emdat.be/ (visited on 06/10/2015).

[18] John T Watson, Michelle Gayer, and Maire A Connolly. “Epidemics after natural disasters”. In: *Emerging Infectious Diseases* 13.1 (2007). DOI: 10.3201/eid1301.060779.

[19] Kimberley I. Shoaf and Steven J. Rottman. “Public health impact of disaster”. In: *Australian Journal of Emergency Management* 15.3 (2000), pp. 58–63.

[20] Food and Agriculture Organization of the United Nations (FAO). *The impact of disasters on agriculture: Addressing the information gap*. Tech. rep. Rome: FAO, 2017. URL: http://www.fao.org/3/a-i7279e.pdf.

[21] I Masih et al. “A review of droughts on the African continent: a geospatial and long-term perspective”. In: *Hydrol. Earth Syst. Sci* 18 (2014), pp. 3635–3649. DOI: 10.5194/hess-18-3635-2014.

[22] Famine Early Warning Systems Network (FEWS NET). *Continuing El Niño drives increased food insecurity across many regions*. Tech. rep. FEWS NET, 2015. URL: http://www.fews.net/global/alert/october-8-2015.

[23] African Development Bank Group. *Development Effectiveness Review 2012 integration - Fragile states and conflict-affected countries*. Tech. rep. Tunis: African Development Bank Group, 2012.

[24] The World Bank. *World development report 2011: Conflict, Security, and Development*. Washington, DC: The World Bank, 2011.

[25] Frances Stewart. “Root causes of violent conflict in developing countries”. In: *BMJ* 324 (2002), pp. 342–5. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1122271/.

[26] C J L Murray et al. “Armed conflict as a public health problem”. In: *Bmj* 324.February (2002), pp. 346–349. ISSN: 1468-5833. DOI: 10.1136/bmj.324.7333.346.

[27] Olivier Degomme and Debarati Guha-Sapir. “Patterns of mortality rates in Darfur conflict”. In: *The Lancet* 375 (2010), pp. 294–300. ISSN: 01406736. DOI: 10.1016/S0140-6736(09)61967-X.

[28] FAO. *The State of Food Insecurity in the World: Addressing food insecurity in protracted crises*. Tech. rep. Rome: FAO, 2010. URL: http://www.fao.org/catalog/inter-e.htm.

[29] Richard Akresh, Philip Verwimp, and Tom Bundervoet. “Civil War, Crop Failure, and Child Stunting in Rwanda”. In: *Economic Development and Cultural Change* 59.4 (2011), pp. 777–810. ISSN: 00130079. DOI: 10.1086/660003.

[30] Debarati Guha-Sapir et al. “Civilian deaths from weapons used in the Syrian conflict”. In: *BMJ* 351.h4736 (2015). DOI: 10.1136/bmj.h4736.

[31] UN IGME. *Levels and Trends in Child Mortality Report 2013. Estimates Developed by UN Inter-agency Group for Child Mortality Estimation (UN IGME)*. Tech. rep. UNICEF, WHO, The World Bank and UN-DESA Population Division, 2013.

[32] Mihai Croicu and Ralph Sundberg. *UCDP Georeferenced Event Dataset Codebook Version 17.1*. Tech. rep. Department of Peace and Conflict Research, Uppsala University, 2017. URL: http://ucdp.uu.se/downloads/ged/ged171.pdf.

[33] Ralph Sundberg and Erik Melander. “Introducing the UCDP Georeferenced Event Dataset”. In: *Journal of Peace Research* 50.4 (2013), pp. 523–532. ISSN: 0022-3433. DOI: 10.1177/0022343313484347.

[34] Girma Amare. “Drought and Famine in Ethiopia and the Effort to Overcome It”. In: *Notre Dame Journal of Law Ethics & Public Policy* 71.3 (1988).

[35] A. Kidane. “Mortality estimates of the 1984-85 Ethiopian famine”. In: *Scandinavian Journal of Public Health* 18.4 (1990), pp. 281–286. ISSN: 1403-4948. DOI: 10.1177/140349489001800409.

[36] Tsegay Wolde-Georgis. “El Niño and Drought Early Warning in Ethiopia”. In: *Internet Journal of African Studies* 2.2 (1997).

[37] Stefan Dercon and Catherine Porter. “Live aid revisited: Long-term impacts of the 1984 Ethiopian famine on children”. In: *Journal of the European Economic Association* 12.4 (2014), pp. 927–948. ISSN: 15424774. DOI: 10.1111/jeea.12088.

[38] Tom Lavers. “Social protection in an aspiring ’developmental state’: The political drivers of Ethiopia’s PSNP”. Manchester, 2016. URL: www.effective-states.org.

[39] Global Water Partnership Eastern Africa (GWPEA). *Assessment of Drought Resilience Frameworks in the Horn of Africa*. Tech. rep. Entebbe: Integrated Drought Management Program in the Horn of Africa (IDMP HOA), 2015.

[40] Bekele Shiferaw et al. “Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options”. In: *Weather and Climate Extremes* 3 (2014), pp. 67–79. ISSN: 22120947. DOI: 10.1016/j.wace.2014.04.004.

[41] Ellen Viste, Diriba Korecha, and Asgeir Sorteberg. “Recent drought and precipitation tendencies in Ethiopia”. In: *Theoretical and Applied Climatology* 112 (2013), pp. 535–551. ISSN: 0177-798X. DOI: 10.1007/s00704-012-0746-3.

[42] Bertelsmann Stiftung. “Bertelsmann Transformation Index 2006”. In: (2006). URL: http://bti2006.bertelsmann-transformation-index.de/fileadmin/pdf/en/2006/EasternAndSouthernAfrica/Ethiopia.pdf.

[43] J. Abbink. “Ethnicity and Conflict Generation in Ethiopia: Some Problems and Prospects of Ethno-Regional Federalism”. In: *Journal of Contemporary African Studies* 24.3 (2006), pp. 389–413. ISSN: 0258-9001. DOI: 10.1080/02589000600976729.

[44] Asnake Kefale Adegehe. “Federalism and ethnic conflict in Ethiopia: a comparative study of the Somali and Benishangul-Gumuz regions”. PhD Dissertation. Leiden University, 2009. URL: https://openaccess.leidenuniv.nl/handle/1887/13839.

[45] IDMC. *Ethiopia Internaly Displaced Peoples (IDP) Figures Analysis*. 2016. URL: http://www.internal-displacement.org/sub-saharan-africa/ethiopia/figures-analysis (visited on 01/12/2017).

[46] OCHA and NDRMC. *Ethiopia: Conflict Displacement Situation Report*. Tech. rep. OCHA and National Disaster Risk Management Commission (NDRMC), 2018.

[47] Amnesty International. “Ethiopia: Draconian state of emergency measures”. 2017. URL: https://www.amnesty.org/en/documents/afr25/5669/2017/en/.

[48] Terrenc Lyons. *Ethiopia: Assessing risks to stability*. Tech. rep. Washington, DC: Center for Strategic and International Studies, 2011.

[49] Lahra Smith. “Political Violence and Democratic Uncertainty in ethiopia”. Washington, DC, 2007.

[50] Richard Akresh, Leonardo Lucchetti, and Harsha Thirumuthy. “Wars and Child Health: Evidence from the Eritrean-Ethiopian conflict”. In: *Journal of Developmental Economy* 99.2 (2012), pp. 330–340. DOI: 10.1016/j.jdeveco.2012.04.001.Wars.

[51] UNICEF. *A UNICEF Policy Review Strategy: Strategy for Improved Nutrition of Children and Women in Developing Countries*. Tech. rep. New York: UNICEF, 1990.

[52] UNHCR and WFP. *Guidelines for selective feeding: The management of malnutrition in emergencies*. Tech. rep. Geneva: UNHCR, 2011. URL: http://resourcecentre.savethechildren.se/library/guidelines-selective-feeding-management-malnutrition-emergencies.

[53] Helen Young and Susanne Jaspars. “The meaning and measurement of acute malnutrition in emergencies: A prime for decision-makers”. London, 2006. URL: https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/492.pdf.

[54] Olaf Müller and Michael Krawinkel. “Malnutrition And Health In Developing Countries”. In: *Canadian Medical Association journal* 173.3 (2005), pp. 279–86. ISSN: 1488-2329. DOI: 10.1503/cmaj.050342.

[55] Robert E. Black et al. “Maternal and child undernutrition: global and regional exposures and health consequences”. In: *The Lancet* 371 (2008), pp. 243–260. ISSN: 01406736. DOI: 10.1016/S0140-6736(07)61690-0.

[56] UNICEF. *The state of the world’s children 1998*. Tech. rep. New York: UNICEF, 1998. URL: https://www.unicef.org/sowc98/sowc98.pdf.

[57] IPC Global Partners. *Intergrated food Security Phase Classification Technical Manual version 2.0: Evidence and Standards for Better Food Security Decisions*. Rome: FAO, 2012. ISBN: 9789251072844.

[58] Nigatu Regassa and Barbara J. Stoecker. “Contextual Risk Factors for Maternal Malnutrition in a Food-Insecure Zone in Southern Ethiopia”. In: *Journal of Biosocial Science* 44 (2012), pp. 537–548. ISSN: 0021-9320. DOI: 10.1017/S002193201200017X.

[59] UNICEF. *UNICEF Humanitarian Action Report 2009*. Tech. rep. Geneva: UNICEF, 2009. URL: https://www.unicef.org/har09/.

[60] Tamuka Magadzire and Gideon Galu. “El Niño update (Horn and Southern Africa focus)”. In: *Global Learning And Evidence Exchange (GLEE) Climate Smart Agriculture: Africa*. Lusaka, Zambia: FEWS NET and USAID, 2016.

[61] Patrice L Engle, Purnima Menon, and Lawrence Haddad. “Care and Nutrition: Concept and Measurement”. In: *World Development* 27.8 (1999), pp. 1309–1337.

[62] Ted Alcorn. “Responding to sexual violence in armed conflict”. In: *The Lancet* 383 (2014), pp. 2034–2037. DOI: 10.1016/S0140-6736(14)60970-3.

[63] Delan Devakumar et al. “The intergenerational effects of war on the health of children”. In: *BMC Medicine* 12.57 (2014). DOI: 10.1186/1741-7015-12-57.

[64] Tais Ariza Alpino, Aderita Ricarda Martins de Sena, and Carlos Machado de Freitas. “Disasters related to droughts and public health – a review of the scientific literature”. In: *Ciência & Saúde Coletiva* 21.3 (2016), pp. 809–820. DOI: 10.1590/1413-81232015213.21392015.

[65] Kristie L. Ebi and Kathryn Bowen. “Extreme events as sources of health vulnerability: Drought as an example”. In: *Weather and Climate Extremes* 11 (2016), pp. 95–102. ISSN: 22120947. DOI: 10.1016/j.wace.2015.10.001.

[66] Carla Stanke et al. “Health Effects of Drought: a Systematic Review of the Evidence”. In: *Plos Crrrents Disasters* (2013), pp. 1–38. DOI: 10.1371/currents.dis.7a2cee9e980f91ad7697b570bcc4b004.

[67] Francesco Checchi et al. “Public health information in crisis-affected populations: a review of methods and their use for advocacy and action”. In: *The Lancet* (2017). DOI: 10.1016/S0140-6736(17)30702-X.

[68] Chiara Altare and Debarati Guha-Sapir. “The Complex Emergency Database: A Global Repository of Small-Scale Surveys on Nutrition, Health and Mortality”. In: *PLoS ONE* 9.10 (2014), e109022. ISSN: 1932-6203. DOI: 10.1371/journal.pone.0109022.

[69] Michelle Gayer et al. “Conflict and emerging infectious diseases”. In: *Emerging Infectious Diseases* 13.11 (2007), pp. 1625–31. ISSN: 10806040. DOI: 10.3201/eid1311.061093.

[70] Yazoume Ye et al. “Health and demographic surveillance systems: a step towards full civil registration and vital statistics system in sub-Sahara Africa”. In: *BMC Public Health* 12.741 (2012). DOI: 10.1186/1471-2458-12-741.

[71] Central Statistical Agency [Ethiopia] and ICF International. *Ethiopia Demographic and Health Survey 2011*. Tech. rep. Addis Ababa and Calverton: CSA and ICF International, 2012. URL: https://dhsprogram.com/pubs/pdf/FR255/FR255.pdf.

[72] Central Statistical Authority (CSA). *2007 Population and Housing Census of Ethiopia: Administrative Report*. Tech. rep. Addis Ababa: CSA, 2012. URL: http://unstats.un.org/unsd/censuskb20/Attachment489.aspx.

[73] Olivier Degomme and Debarati Guha-Sapir. “Mortality and nutrition surveys by non-governmental organisations. Perspectives from the CE-DAT database”. In: *Emerging themes in epidemiology* 4.11 (2007). ISSN: 1742-7622. DOI: 10.1186/1742-7622-4-11.

[74] Central Statistical Agency (CSA). *Population Projection of Ethiopia for All Regions at Wereda Level from 2014–2017*. Tech. rep. Addis Ababa: CSA, 2013.

[75] Oliver Walton. *Preventing conflict between refugees and host communities*. Tech. rep. Birmingham: University of Birmingham, 2012. URL: http://www.gsdrc.org/docs/open/hdq845.pdf.

[76] Kelsey Lilley. *Gambella Attack Exposes Ethnic Tensions between Ethiopia, South Sudan*. 2016. URL: http://www.atlanticcouncil.org/blogs/africasource/gambella-attack-exposes-ethnic-tensions-between-ethiopia-south-sudan (visited on 05/05/2017).

[77] Stephen S Lim et al. “Measuring the health-related Sustainable Development Goals in 188 countries: a baseline analysis from the Global Burden of Disease Study 2015”. In: *Lancet* 388 (2016), pp. 1813–50. DOI: 10.1016/S0140-6736(16)31467-2.

[78] WHO. *World health statistics 2016: monitoring health for the SDGs, Sustainable Development Goals*. Tech. rep. Geneva: WHO, 2016.

[79] Ethiopia Population Census Commission. *Summary and Statistical Report of the 2007 Population and Housing Census Results*. Tech. rep. Addis: Central Statistical Agency, 2008.

[80] The World Bank. *Atlas of Sustainable Development Goals*. 2017, p. 131. ISBN: 9781464810800.

[81] National Planning Commission and the United Nations in Ethiopia. *Millennium Development Goals Report 2014 Ethiopia: Assessment of Ethiopia's Progress towards the MDGs*. Tech. rep. Addis Ababa: National Planning Commission and the United Nations in Ethiopia, 2015. URL: http://www.et.undp.org/content/ethiopia/en/home/library/mdg/EthiopiaMDG2014.html.

[82] UNDP. *Work for human development: Briefing note for countries on the 2015 Human Development Report - Ethiopia*. Tech. rep. UNDP, 2016.

[83] Ministry of Health Ethiopia et al. *Success factors for women's and children's health: Ethiopia*. World Health Organization, 2015.

[84] Central Statistical Agency (CSA) [Ethiopia] and ICF. *Ethiopia Demographic and Health Survey 2016*. Tech. rep. Addis Ababa and Rockville: CSA and ICF, 2016. URL: https://dhsprogram.com/pubs/pdf/FR328/FR328.pdf.

[85] Central Statistical Authority (CSA) [Ethiopia] and ORC Macro. *Ethiopia Demographic and Health Survey 2005*. Tech. rep. Addis Ababa and Calverton: CSA and ORC Macro, 2006.

[86] WHO. "Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee." Geneva, 1995.

[87] WHO. *World Health Statistics 2015: Global Health Indicators*. Tech. rep. Geneva: WHO, 2015.

[88] Robert E. Black et al. "Maternal and child undernutrition and overweight in low-income and middle-income countries". In: *The Lancet* 382 (2013), pp. 427–51. ISSN: 01406736. DOI: 10.1016/S0140-6736(13)60937-X.

[89] Mercedes de Onis, Monika Blössner, and Elaine Borghi. "Prevalence and trends of stunting among pre-school children, 1990–2020". In: *Public Health Nutrition* 15 (2012), pp. 142–148. ISSN: 1368-9800. DOI: 10.1017/S1368980011001315.

[90] Mercedes de Onis et al. "Comparison of the World Health Organization (WHO) Child Growth Standards and the National Center for Health Statistics/WHO international growth reference: implications for child health programmes". In: *Public Health Nutrition* 9.07 (2007), pp. 942–7. ISSN: 1368-9800. DOI: 10.1017/PHN20062005.

[91] WHO Multicentre Growth Reference Study Group. *WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development*. Tech. rep. Geneva: WHO, 2006. DOI: 10.4067/S0370-41062009000400012.

[92] Hong Yang and Mercedes de Onis. “Algorithms for converting estimates of child malnutrition based on the NCHS reference into estimates based on the WHO Child Growth Standards”. In: *BMC pediatrics* 8 (2008), p. 19. ISSN: 1471-2431. DOI: 10.1186/1471-2431-8-19.

[93] Youfa Wang and Hsin-Jen Chen. “Use of Percentiles and Z -Scores in Anthropometry”. In: *Handbook of Anthropometry:Physical Measures*. Ed. by V.R. Preedy. Springer, 2012. Chap. 2, pp. 29–48. ISBN: 978-1-4419-1787-4. DOI: 10.1007/978-1-4419-1788-1.

[94] Francesco Checchi and Les Roberts. “Interpreting and using mortality data in humanitarian emergencies. A primer for non-epidemiologists”. London, 2005. URL: http://www.odihpn.org/documents/networkpaper052.pdf.

[95] Francesco Checchi and Les Roberts. “Documenting mortality in crises: what keeps us from doing better?” In: *PLoS medicine* 5.7 (2008), e146. ISSN: 1549-1676. DOI: 10.1371/journal.pmed.0050146.

[96] The SMART Project. *Measuring Mortality, Nutritional Status, and Food Security in Crisis Situations: SMART METHODOLOGY*. Version 1. 2006.

[97] IPCC. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change*. Ed. by C.B. Field et al. Cambridge and New York: Cambridge University Press, 2012, p. 594. ISBN: 978-1-107-02506-6.

[98] Santiago Beguería, Sergio M. Vicente-Serrano, and Marta Angulo-Martínez. “A Multiscalar Global Drought Dataset: The SPEIbase: A New Gridded Product for the Analysis of Drought Variability and Impacts”. In: *Bulletin of the American Meteorological Society* 91.10 (2010), pp. 1351–1356. ISSN: 0003-0007. DOI: 10.1175/2010BAMS2988.1.

[99] Richard R. Heim. “A review of twentieth-century drought indices used in the United States”. In: *Bulletin of the American Meteorological Society* 83.8 (2002), pp. 1149–1165. ISSN: 00030007. DOI: 10.1175/1520-0477(2002)083<1149:AROTDI>2.3.CO;2.

[100] Amin Zargar et al. “A review of drought indices”. In: *Environmental Reviews* 19 (2011), pp. 333–349. ISSN: 1181-8700. DOI: 10.1139/a11-013.

[101] Sergio M. Vicente-Serrano, Santiago Begueria, and Juan I. Lopez-Moreno. “A multiscalar drought index sensitive to global warming: The standardized precipitation evapotranspiration index”. In: *Journal of Climate* 23.7 (2010), pp. 1696–1718. ISSN: 08948755. DOI: 10.1175/2009JCLI2909.1.

[102] Food and Agriculture Organization of the United Nations (FAO). “World Food Summit”. In: *Rome Declaration on World Food Security*. Rome: FAO, 1996. URL: http://www.fao.org/docrep/003/w3613e/w3613e00.HTM.

[103] Clionadh Raleigh et al. “Introducing ACLED-Armed Conflict Location and Event Data”. In: *Journal of Peace Research* 47.5 (2010), pp. 651–660. DOI: 10.1177/0022343310378914.

[104] T. Pettersson and P. Wallensteen. “Armed conflicts, 1946-2014”. In: *Journal of Peace Research* 52.4 (2015), pp. 536–550. ISSN: 0022-3433. DOI: 10.1177/0022343315595927.

[105] Emmanuel Lesaffre and Andrew B. Lawson. *Bayesian Biostatistics*. A John Wiley and Sons, Ltd., Publication, 2012. ISBN: 9780470018231.

[106] Rens van de Schoot et al. “A gentle introduction to bayesian analysis: applications to developmental research.” In: *Child development* 85.3 (2014), pp. 842–60. ISSN: 1467-8624. DOI: 10.1111/cdev.12169.

[107] Food and Drug Administration (FDA). *Guidance for the use of Bayesian statistics in medical device clinical trials*. Tech. rep. Center for Biologics Evaluation and Research, 2010. URL: https://www.fda.gov/MedicalDevices/ucm071072.htm.

[108] Luce O’Hagan. *A primer on Bayesian Statistics in Health Economics and Outcomes Research*. 2003, pp. 455–475. ISBN: 978-0-89871-002-1. DOI: 10.2307/2347923.

[109] Mark E Glickman and David a van Dyk. “Basic Bayesian methods”. In: *Methods in Molecular Biology: Topics in Biostatistics*. Ed. by Walter T. Ambrosius. Vol. 404. Humana Press Inc., 2007, pp. 319–338. ISBN: 978-1-58829-531-6. DOI: 10.1007/978-1-59745-530-5_16.

[110] D J Spiegelhalter et al. “Bayesian methods in health technology assessment: a review”. In: *Health technology assessment* 4.38 (2000). ISSN: 1366-5278.

[111] Alex J Sutton and Keith R Abrams. “Bayesian methods in meta-analysis and evidence synthesis”. In: *Statistical Methods in Medical Research* 10 (2001), pp. 277–303. DOI: 10.1177/096228020101000404.

[112] Wolfgang Viechtbauer. “Conducting Meta-Analyses in R with the metafor Package”. In: *Journal of Statistical Software* 36.3 (2010). DOI: 10.18637/jss.v036.i03.

[113] Jonathan J Deeks, Julian PT Higgins, and Douglas G Altman. “Chapter 9: Analysing data and undertaking meta-analyses”. In: *Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 (updated March 2011)*. Ed. by Julian PT Higgins and S Green. The Cochrane Collaboration, 2011. URL: www.cochrane-handbook.org.

[114] Mark W. Lipsey and David B. Wilson. *Practical Meta Analysis Overview*. SAGE Publications, 2001.

[115] Julian P Higgins, Simon G Thompson, and David J Spiegelhalter. “A re-evaluation of random-effects meta-analysis”. In: *Journal of the Royal Statistical Society* 172.1 (2009), pp. 137–159. DOI: 10.1111/j.1467-985X.2008.00552.x.

[116] Julian P Higgins and Simon G Thompson. “Quantifying heterogeneity in a meta-analysis”. In: *Statistics in Medicine* 21 (2002), pp. 1539–1558. ISSN: 02776715. DOI: 10.1002/sim.1186.

[117] Julian P T Higgins et al. “Measuring inconsistency in meta-analyses”. In: *BMJ* 327.7414 (2003), pp. 557–560. ISSN: 1756-1833. DOI: 10.1136/bmj.327.7414.557.

[118] Joseph Lau, John P A Ioannidis, and Christopher H. Schmid. "Summing up evidence: One answer is not always enough". In: *Lancet* 351.9096 (1998), pp. 123–127. ISSN: 01406736. DOI: 10.1016/S0140-6736(97)08468-7.

[119] Matthias Egger and George Davey Smith. "Bias in location and selection of studies". In: *BMJ* 316.7124 (1998), pp. 61–66. ISSN: 0959-8138. DOI: 10.1136/bmj.316.7124.61.

[120] Alessandro Liberati et al. "The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration". In: *BMJ* 339 (2009), b2700. DOI: 10.1136/BMJ.B2700.

[121] Ana V. Diez-Roux. "Multilevel Analysis in Public Health Research". In: *Annual Reviews Public Health* 21 (2000), pp. 171–192. ISSN: 0163-7525. DOI: 10.1146/annurev.publhealth.21.1.171.

[122] Jon Rasbash et al. *A user's guide to MLwiN*. Bristol, 2014.

[123] Harvey Goldstein. *Multilevel Statistical Models*. Ed. by David J. Balding et al. 4th ed. JohnWiley & Sons, Ltd, 2011. ISBN: 9780470973394.

[124] Debarati Guha-Sapir and Olivia D'Aoust. "Demographic and Health Consequences of Civil Conflict". Washington, DC, 2010. URL: http://hdl.handle.net/10986/9083.

[125] Tefera Darge Delbiso et al. "Health at the borders: Bayesian multilevel analysis of women's malnutrition determinants in Ethiopia". In: *Global health action* 9 (2016), p. 30204. ISSN: 1654-9880. DOI: 10.3402/gha.v9.30204.

[126] Camelia Minoiu and Olga N. Shemyakina. "Armed conflict, household victimization, and child health in Cote d'Ivoire". In: *Journal of Development Economics* 108 (2014), pp. 237–255. ISSN: 03043878. DOI: 10.1016/j.jdeveco.2014.03.003.

[127] Pedram Rowhani et al. "Malnutrition and conflict in East Africa: The impacts of resource variability on human security". In: *Climatic Change* 105 (2011), pp. 207–222. ISSN: 01650009. DOI: 10.1007/s10584-010-9884-8.

[128] Tagel Gebrehiwot, Anne van der Veen, and Ben Maathuis. "Spatial and temporal assessment of drought in the Northern highlands of Ethiopia". In: *International Journal of Applied Earth Observation and Geoinformation* 13.3 (2011), pp. 309–321. ISSN: 03032434. DOI: 10.1016/j.jag.2010.12.002.

[129] Uppsala Conflict Data Program. *UCDP Conflict Encyclopedia*. Tech. rep. Uppsala: Uppsala Universitet, 2016. URL: www.ucdp.uu.se/database,UppsalaUniversity.

[130] Michael Geiger and Lars Christian Moller. *Ethiopia Economic Update II: Laying the Foundation for Achieving Middle Income Status*. Tech. rep. Washington DC: World Bank Group, 2013. URL: http://documents.worldbank.org/curated/en/2013/06/18594155/ethiopia-second-economic-update-laying-foundation-achieving-middle-income-status.

[131] Ruth Hill and Eyasu Tsehaye. “Ethiopia Poverty Assessment 2014”. Washington, DC, 2015. URL: http://hdl.handle.net/10986/21323.

[132] Central Statistical Agency (CSA) Ethiopia. *Ethiopia Mini Demographic and Health Survey 2014*. Tech. rep. Addis Ababa: CSA, 2014, p. 111.

[133] African Union Comission et al. *The Cost of Hunger in Africa: Social and Economic Impact of Child Undernutrition in Egypt, Ethiopia, Swaziland and Uganda*. Tech. rep. Addis Ababa: UN Economic Commission for Africa, 2014.

[134] WHO. *The management of nutrition in major emergencies*. Geneva: WHO, 2000.

[135] Isaack B. Manyama, Gugsa Abate, and Mathewos Tamiru. “The Emergency Nutrition Coordination Unit of Ethiopia: roles, responsibilities and achievements”. 2011. URL: http://www.ennonline.net/fex/40.

[136] Thomas B Mckee, Nolan J Doesken, and John Kleist. “The relationship of drought frequency and duration to time scales”. In: *AMS 8th Conference on Applied Climatology*. January. 1993, pp. 179–184.

[137] RStudio Team. *RStudio: Integrated Development for R*. Boston, MA, 2015. URL: http://www.rstudio.com/.

[138] The World Bank. *Ethiopia’s Productive Safety Net Program (PSNP) Integrating Disaster And Climate Risk Management*. Tech. rep. 1. Washington DC: The World Bank Group, 2013, p. 19.

[139] Kassahun Bedada Beyi. “The Evolution of Ethiopian Government’s Early Warning System”. 2011. URL: http://www.ennonline.net/fex/40/evolution.

[140] A De Waal, A Seyoum Taffesse, and L Carruth. “Child survival during the 2002-2003 drought in Ethiopia”. In: *Global public health* 1.2 (2006), pp. 125–32. ISSN: 1744-1706. DOI: 10.1080/17441690600661168.

[141] Helen Young et al. “Public nutrition in complex emergencies”. In: *Lancet* 364.9448 (2004), pp. 1899–1909. ISSN: 01406736. DOI: 10.1016/S0140-6736(04)17447-3.

[142] Florence Egal. “Nutrition in conflict situations”. In: *British Journal of Nutrition* 96 (2006), S17–S19. ISSN: 0007-1145. DOI: 10.1079/BJN20061692.

[143] Chiara Altare, Tefera Darge Delbiso, and Debarati Guha-sapir. “Child Wasting in Emergency Pockets: A Meta-Analysis of Small-Scale Surveys from Ethiopia”. In: *International Journal of Environmental Research and Public Health* 13.2 (2016). DOI: 10.3390/ijerph13020178.

[144] The World Bank and The United Nations. *Natural hazards, unnatural disasters : the economics of effective prevention*. Washington, DC: The World Bank, 2010. ISBN: 9780821380505.

[145] A Taye, D Hailemariam, and V Murray. “Interim report: Review of evidence of the health impact of famine in Ethiopia”. In: *Perspectives in Public Health* 130.5 (2010), pp. 222–226. DOI: 10.1177/1757913910379197.

[146] William J Moss et al. “Child health in complex emergencies”. In: *Bulletin of the World Health Organization* 84.1 (2006), pp. 58–64. DOI: 10.2471/BLT.04.019570.

[147] Peter Salama et al. “Malnutrition,Measles, Mortality, and the Humanitarian Response During a Famine in Ethiopia”. In: *JAMA* 286.5 (2001), pp. 563–571. DOI: 10.1001/jama.286.5.563.

[148] Francesco Checchi and W. Courtland Robinson. *Mortality among populations of southern and central Somalia affected by severe food insecurity and famine during 2010-2012*. Tech. rep. Rome, Washington: FAO/FSNAU and FEWS NET, 2013.

[149] Working Group for Mortality Estimation in Emergencies. “Wanted: studies on mortality estimation methods for humanitarian emergencies, suggestions for future research”. In: *Emerging themes in epidemiology* 4 (2007), p. 9. ISSN: 1742-7622. DOI: 10.1186/1742-7622-4-9.

[150] Tefera Darge Delbiso et al. “Drought, conflict and children’s undernutrition in Ethiopia 2000–2013: a meta-analysis”. In: *Bull World Health Organ* 95 (2017), pp. 94–102. DOI: 10.2471/BLT.16.172700.

[151] Matthew J Spittal, Jane Pirkis, and Lyle C Gurrin. “Meta-analysis of incidence rate data in the presence of zero events”. In: *BMC medical research methodology* 15 (2015), p. 42. ISSN: 1471-2288. DOI: 10.1186/s12874-015-0031-0.

[152] David Spiegelhalter et al. *WinBUGS User Manual*. 2003. URL: http://www.mrc-bsu.cam.ac.uk/bugs.

[153] The Sphere Project. *The Sphere Project: Humanitarian Charter and Minimum Standards in Humanitarian Response*. 3rd ed. Rugby: Practical Action Publishing, 2011. URL: http://www.sphereproject.org/.

[154] Abebe Alebachew, Laurel Hatt, and Matthew Kukla. “Monitoring and Evaluating Progress towards Universal Health Coverage in Ethiopia”. In: *PLoS Medicine* 11.9 (2014). ISSN: 15491676. DOI: 10.1371/journal.pmed.1001696.

[155] Li Liu et al. “Global, regional, and national causes of under-5 mortality in 2000-15: an updated systematic analysis with implications for the Sustainable Development Goals”. English. In: *Lancet* (2016). ISSN: 1474-547X. DOI: 10.1016/S0140-6736(16)31593-8.

[156] The Federal Democratic Republic of Ethiopia (FDRE). *National Policy And Strategy on Disaster Risk Management*. Tech. rep. Addis Ababa: FDRE, 2013. URL: https://www.dppc.gov.et/downloadable/Documentation/EthiopiaDRMPolicy{_}ENG2014.pdf.

[157] Daniel O Gilligan, John Hoddinott, and Alemayehu Seyoum Taffesse. “The Impact of Ethiopia’s Productive Safety Net Programme and its Linkages”. In: *The Journal of Development Studies* 45.10 (2009), pp. 1684–1706. ISSN: 00220388. DOI: 10.1080/00220380902935907.

[158] D L Pelletier et al. “The effects of malnutrition on child mortality in developing countries”. In: *Bulletin of the World Health Organization* 73.4 (1995), pp. 443–8. ISSN: 0042-9686.

[159] Ashley A. Campbell et al. “Relationship of household food insecurity to neonatal, infant, and under-five child mortality among families in rural Indonesia”. In: *Food and nutrition bulletin* 30.2 (2009), pp. 112–119. ISSN: 03795721. DOI: 10.1177/156482650903000202.

[160] WHO. *The World Health Report 2005: Make every mother and child count*. Tech. rep. Geneva: WHO, 2005.

[161] Fikrewold H. Bitew and Daniel S. Telake. “Undernutrition among Women in Ethiopia”. Calverton, Maryland, USA: ORC Macro, 2010. URL: http://www.dhsprogram.com/pubs/pdf/WP77/WP77.pdf.

[162] Altrena Mukuria, Casey Aboulafia, and Albert Themme. “The context of Women’s Health: Results from the Demographic and Health Surveys, 1994-2001”. Calverton, Maryland, 2005. URL: https://dhsprogram.com/pubs/pdf/CR11/CR11.pdf.

[163] Daniel J. Corsi, Jocelyn E. Finlay, and S.V. Subramanian. “Weight of communities: A multilevel analysis of body mass index in 32,814 neighborhoods in 57 low- to middle-income countries (LMICs)”. In: *Social Science & Medicine* 75.2 (2012), pp. 311–322. ISSN: 02779536. DOI: 10.1016/j.socscimed.2012.02.014.

[164] Yibeltal Tebekaw, Charles Teller, and Uriyoán Colón-Ramos. “The burden of underweight and overweight among women in Addis Ababa, Ethiopia”. In: *BMC Public Health* 14 (2014), p. 1126. ISSN: 1471-2458. DOI: 10.1186/1471-2458-14-1126.

[165] Woldemariam Girma and Timotiows Genebo. *Determinants of Nutritional Status of Womens and Children in Ethiopia*. Tech. rep. Calverton, Maryland: ORC Macro, 2002. URL: https://dhsprogram.com/pubs/pdf/FA39/02-nutrition.pdf.

[166] Dereje Feyissa and Markus V. Hoehne. “Resourcing State Borders and Borderlands in the Horn of Africa”. Halle/Saale, Germany, 2008.

[167] John Markakis. “Borders and Borderland Communities in the Horn: The Failure of Integration”. In: *Divided They Stand: the affordances of state borders in the Horn of Africa*. Ed. by Dereje Feyissa and Markus Höhne. Halle/Saale, Germany: Max Planck Institute for Social Anthropology, 2006.

[168] Annette Weber. *Boundaries with Issues: Soft Border Management as a Solution?* Tech. rep. Berlin: Friedrich-Ebert-Stiftung, Africa Department, 2012. URL: http://library.fes.de/pdf-files/iez/08869.pdf.

[169] Francis Nguendi Ikome. “Africa’s international borders as potential sources of conflict and future threats to peace and security”. Addis Ababa, Ethiopia, 2012.

[170] Javier E. Baez. “Civil wars beyond their borders: The human capital and health consequences of hosting refugees”. In: *Journal of Development Economics* 96.2 (2011), pp. 391–408. ISSN: 03043878. DOI: 10.1016/j.jdeveco.2010.08.011.

[171] Denis Cogneau, Sandrine Mesple-somps, and Gilles Spielvogel. "Development at the border: a study of national integration in post-colonial West Africa". 2010. URL: https://halshs.archives-ouvertes.fr/halshs-00966312.

[172] William J Browne. *MCMC estimation in MLwiN*. Bristol, 2014.

[173] George Leckie and Chris Charlton. "runmlwin : A Program to Run the MLwiN Multilevel Modeling Software from within Stata". In: *Journal of Statistical Software* 52.11 (2012). ISSN: 15487660. DOI: 10.18637/jss.v052.i11.

[174] QGIS Development Team. *QGIS Geographic Information System. Open Source Foundation Project*. 2015. URL: http://qgis.osgeo.org.

[175] Tobias J Lanz. "Environmental Degradation and Social Conflict in the Northern Highlands of Ethiopia: The Case of Tigray and Wollo Provinces". In: *Africa Today* 43.2 (1996), pp. 157–182. ISSN: 00019887.

[176] Sara Pantuliano and Mike Wekesa. *Improving drought response in pastoral regions of Ethiopia: Somali and Afar regions and Borena Zone in Oromiya region*. Tech. rep. London: Humanitarian Policy Group (HPG), ODI - Overseas Development Institute, 2008. URL: http://www.alnap.org/resource/7510.

[177] S. Rettberg. "Contested narratives of pastoral vulnerability and risk in Ethiopia's Afar region". In: *Pastoralism* 1.2 (2010), pp. 248–273. ISSN: 2041-7136. DOI: 10.3362/2041-7136.2010.014.

[178] Stephen Devereux. "Vulnerable Livelihoods in Somali Region, Ethiopia". Brighton, 2006. URL: https://www.ids.ac.uk/files/Rr57.pdf.

[179] Dereje Feyissa. "A National Perspective on the Conflict in Gambella". In: *Proceedings of the 16th International Conference of Ethiopian Studies*. Ed. by Svein Ege et al. Trondheim, 2009, pp. 641–654. URL: http://portal.svt.ntnu.no/sites/ices16/Proceedings/Volume2/DerejeFeyissa-ANationalPerspectiveontheConflictinGambella.pdf.

[180] Tobias Hagmann and Alemmaya Mulugeta. "Pastoral Conflicts and State-Building in the Ethiopian Lowlands". In: *African Spectrum* 43.1 (2008), pp. 19–37.

[181] Karen Jacobsen. "Can refugees benefit the state? Refugee resources and African statebuilding". In: *The Journal of Modern African Studies* 40 (2002). ISSN: 0022-278X. DOI: 10.1017/S0022278X02004081.

[182] Sarah Meyer et al. "Refugee site health service utilization: More needs to be done". In: *American Journal of Disaster Medicine* 6.4 (2011), pp. 231–242. DOI: DOI:10.5055/ajdm.2011.0062.

[183] Jennifer Alix-Garcia et al. "Do refugee camps help or hurt hosts? The case of Kakuma, Kenya". In: *Journal of Development Economics* 130 (2017), pp. 66–83. DOI: 10.1016/j.jdeveco.2017.09.005.

[184] Jennifer Alix-Garcia and David Saah. “The effect of refugee inflows on host communities: Evidence from Tanzania”. In: *World Bank Economic Review* 24.1 (2009), pp. 148–170. ISSN: 02586770. DOI: https://doi.org/10.1093/wber/lhp014.

[185] J G Montalvo and M Reynal-Querol. “Fighting against malaria: Prevent wars while waiting for the "miraculous" vaccine”. In: *The Review of Economics and Statistics* 89.1 (2007), pp. 165–177. ISSN: 0034-6535. DOI: 10.1162/rest.89.1.165.

[186] Kate Sadler et al. *Milk Matters: A Literature Review of Pastoralist Nutrition and Programming Responses*. Tech. rep. Addis Ababa: Feinstein International Center, Tufts University and Save the Children, 2009. URL: http://www.alnap.org/resource/10027.

[187] Tsegaye Demissie, Yared Mekonen, and Jemal Haider. “Agroecological comparison of levels and correlates of nutritional status of women”. In: *Ethiopian Journal of Health Development* 17.3 (2003), pp. 189–96.

[188] WHO. *Poverty and Health*. Tech. rep. Geneva: WHO, 2003. DOI: 10.1787/9789264100206-en.

[189] Ngianga-Bakwin Kandala and Gebrenegus Ghilagaber, eds. *Advanced Techniques for Modelling Maternal and Child Health in Africa*. Vol. 34. The Springer Series on Demographic Methods and Population Analysis. Dordrecht: Springer Netherlands, 2014. ISBN: 978-94-007-6777-5. DOI: 10.1007/978-94-007-6778-2.

[190] Melissa Neuman et al. “The poor stay thinner: Stable socioeconomic gradients in BMI among women in lower- and middle-income countries”. In: *American Journal of Clinical Nutrition* 94 (2011), pp. 1348–1357. ISSN: 00029165. DOI: 10.3945/ajcn.111.018127.

[191] S V Subramanian and George Davey Smith. “Patterns, distribution, and determinants of under- and overnutrition: a population-based study of women in India”. In: *American Journal of Clinical Nutrition* 84.3 (2006), pp. 633–640. DOI: 10.1093/ajcn/84.3.633.

[192] Duncan Mara et al. “Sanitation and Health”. In: *PLoS Medicine* 7.11 (2010), e1000363. ISSN: 1549-1676. DOI: 10.1371/journal.pmed.1000363.

[193] Charles Teller and Tesfayi Gebreselassie. “Religious, Ethnic, and Regional Factors of High Fertility in Ethiopia”. In: *Population Reference Bureau* (2009). URL: http://www.prb.org/Publications/Articles/2009/ethiopiamuslimdemographics.aspx.

[194] Agustin Conde-Agudelo et al. “Effects of Birth Spacing on Maternal, Perinatal, Infant, and Child Health: A Systematic Review of Causal Mechanisms”. In: *Studies In Family Planning* 43.2 (2012), pp. 93–114. ISSN: 1097-6868. DOI: 10.1016/j.ajog.2006.05.055.

[195] Barry M Popkin, Linda S Adair, and Shu Wen Ng. “NOW AND THEN: The Global Nutrition Transition: The Pandemic of Obesity in Developing Countries”. In: *Nutrition reviews* 70.1 (2012), pp. 3–21. ISSN: 1753-4887. DOI: 10.1111/j.1753-4887.2011.00456.x.

[196] Carlos S. Grijalva-Eternod et al. “The Double Burden of Obesity and Malnutrition in a Protracted Emergency Setting: A Cross-Sectional Study of Western Sahara Refugees”. In: *PLoS Medicine* 9.10 (2012). ISSN: 15491277. DOI: 10.1371/journal.pmed.1001320.

[197] Ethiopian Public Health Association (EPHA) and Centers for Disease Control and Prevention (CDC). *Ethiopian Universities Health and Demographic Surveillance System: Network Data Sharing and Release Policy*. Tech. rep. Addis Ababa: EPHA and CDC, 2013.

[198] Ethiopian Federal Ministry of Health (FMoH). *National Nutrition Strategy*. Tech. rep. Addis Ababa: FMoH, 2008.

[199] Richard Akresh et al. “War and Stature: Growing Up During the Nigerian Civil War”. 2011. URL: http://ftp.iza.org/dp6194.pdf.

[200] Lambed Tatah et al. “Impact of Refugees on Local Health Systems: A Difference-in-Differences Analysis in Cameroon”. In: *PLoS ONE* 11.12 (2016), e0168820. DOI: 10.1371/journal.pone.0168820.

[201] Surya Gaire et al. “Impact of disasters on child stunting in Nepal”. In: *Risk Management and Healthcare Policy* 9 (2016), pp. 113–127. ISSN: 1179-1594. DOI: 10.2147/RMHP.S101124.

[202] John B. Mason et al. “Child acute malnutrition and mortality in populations affected by displacement in the horn of Africa, 1997-2009”. In: *International Journal of Environmental Research and Public Health* 9 (2012), pp. 791–806. ISSN: 16604601. DOI: 10.3390/ijerph9030791.

[203] Jens Nielsen, Claudine Prudhon, and Xavier de Radigues. “Trends in malnutrition and mortality in Darfur, Sudan, between 2004 and 2008: A meta-analysis of publicly available surveys”. In: *International Journal of Epidemiology* 40.4 (2011), pp. 971–984. ISSN: 03005771. DOI: 10.1093/ije/dyr010.

[204] Debarati Guha-Sapir and Ruwan Ratnayake. “Consequences of ongoing civil conflict in Somalia: Evidence for public health responses”. In: *PLoS Medicine* 6.8 (2009). ISSN: 15491277. DOI: 10.1371/journal.pmed.1000108.

[205] Revati K Phalkey et al. “Systematic review of current efforts to quantify the impacts of climate change on undernutrition”. In: *Proceedings of the National Academy of Sciences* 112.33 (2015), E4522–E4529. ISSN: 1091-6490. DOI: 10.1073/pnas.1409769112.

[206] Amdissa Teshome. “Agriculture, Growth and Poverty Reduction in Ethiopia: Policy Processes Around the New PRSP (PASDEP)”. 2006. URL: www.future-agricultures.org.

[207] Henk-Jan Brinkman and Cullen S Hendrix. “Food Insecurity and Violent Conflict: Causes, Consequences, and Addressing the Challenges”. 2011. URL: https://ucanr.edu/blogs/food2025/blogfiles/14415.pdf.

[208] S Mansoob Murshed. “Conflict, Civil War and Underdevelopment: An Introduction”. In: *Journal of Peace Research* 39.4 (2002), pp. 387–393. DOI: 10.1177/0022343302039004001.

[209] Wadie Wanies Kamel. “Health dilemmas at the borders - a global challenge”. In: *World Health Forum* 18.1 (1997), pp. 9–16.

[210] Tungamirirai Simbini et al. “Monitoring diseases across borders: African regional integrative information systems”. In: *Studies in Health Technology and Informatics* 160.PART 1 (2010), pp. 401–405. ISSN: 09269630. DOI: 10.3233/978-1-60750-588-4-401.

[211] Laura Hammond. “Strategies of Invisibilization: How Ethiopia’s Resettlement Programme Hides the Poorest of the Poor”. In: *Journal of Refugee Studies* 21.4 (2008), pp. 517–536. ISSN: 0951-6328. DOI: 10.1093/jrs/fen041.

[212] Guush Berhane et al. *The impact of Ethiopia’s Productive Safety Nets and Household Asset Building Programme: 2006-2010*. Tech. rep. Washington DC: International Food Policy Research Institute, 2011.

[213] Bethelhem L. Debela, Gerald Shively, and Stein T. Holden. “Does Ethiopia’s Productive Safety Net Program improve child nutrition?” In: *Food Security* 7.6 (2015), pp. 1273–1289. ISSN: 1876-4517. DOI: 10.1007/s12571-015-0499-9.

[214] Transitional Government of Ethiopian (TGE). *Health Policy of the Transitional Government of Ethiopia*. Addis Ababa: TGE, 1993.

[215] Huihui Wang et al. *Ethiopia Health Extension Program: An Institutionalized Community Approach for Universal Health Coverage*. Tech. rep. The World Bank, 2016. URL: https://openknowledge.worldbank.org/bitstream/handle/10986/24119/9781464808159.pdf?sequence=2.

[216] Assefa Admassie, Degnet Abebaw, and Andinet D. Woldemichael. “Impact evaluation of the Ethiopian Health Services Extension Programme”. In: *Journal of Development Effectiveness* 1.4 (2009), pp. 430–449. ISSN: 1943-9342. DOI: 10.1080/19439340903375724.

[217] Nicholas Kassebaum et al. “Child and Adolescent Health From 1990 to 2015: Findings From the Global Burden of Diseases, Injuries, and Risk Factors 2015 Study”. In: *JAMA Pediatrics* 123.1 (2017), pp. 199–206. ISSN: 2168-6203. DOI: 10.1001/jamapediatrics.2017.0250.

[218] James P. Wirth et al. “Scale up of nutrition and health programs in Ethiopia and their overlap with reductions in child stunting”. In: *Maternal and Child Nutrition* 13.2 (2017). DOI: 10.1111/mcn.12318.

[219] Government of the Federal Democratic Republic of Ethiopia (FDRE). *National Nutrition Programme*. Tech. rep. Addis Ababa: FDRE, 2013.

[220] Ethiopian Central Statistical Agency (CSA) and the World Food Programme (WFP). *Comprehensive Food Security and Vulnerability Analysis (CFSVA)*. Tech. rep. Addis Ababa: CSA and the WFP, 2014. URL: http://documents.wfp.org/stellent/groups/public/documents/ena/wfp265490.pdf.

[221] Emergency Nutrition Network (ENN). “Analysis of Nutrition Surveys in Ethiopia”. In: *Contextual information collection in emergency nutrition assessments in Ethiopia*. Ed. by Emergency Nutrition Network. Field Exchange. Emergency Nutrition Network. Addis Ababa: Emergency Nutrition Network, 2009. URL: http://www.ennonline.net/fex/37/contextual.

[222] Tefera Darge Delbiso et al. “Drought and child mortality: a meta-analysis of small-scale surveys from Ethiopia”. In: *Scientific reports* 7.1 (2017), p. 2212. DOI: 10.1038/s41598-017-02271-5.

Appendix A

CE-DAT Completeness Checklist Form

Pre-survey preparation and planning

Objective of the survey
1) Nutrition YES NO
2) Mortality YES NO
3) Vaccination YES NO

Population
4) Type of population stated YES NO
5) Total population in universe stated YES NO

Location
6) Geographical scope of the survey stated YES NO
7) Area excluded from sampling frame listed YES NO NA

Time period
8) Survey dates are stated ((dd-)mm-yyyy) YES NO

Translation
9) Language of the questionnaire is stated YES NO
10) Language of the interview is stated YES NO

Questionnaire/tool
11) Pre-testing of questionnaire stated YES NO
12) Use of local event calendar stated YES NO

Training
13) Training organisation stated YES NO

Methods

Sampling design
15-16 only if cluster sampling, ↳ 17 for other sampling designs
14) State type of sampling design & rationale YES NO
15) State if PPS was used YES NO NA
16) Number of clusters ☐ x ☐

Final stage
18 only if nutrition module included, otherwise ↳ 19
17) State final stage sampling method YES NO NA
18) State if HH without U5 were included YES NO
19) State if oversampling was used YES NO

Household
21 only if mortality module included, otherwise ↳ 22
20) State definition of HH YES NO
21) State selection of U5 in the HH YES NO NA
22) HH selection in a compound is explained YES NO NA
23) Respondent stated (responsible adult) YES NO

Sample size precision
24-26 only if nutrition module included, ↳ 27 ; 27-29 only if mortality module included, otherwise ↳ 30
24) Expected GAM: ☐ Stated why? YES NO NA
25) Expected Deff for GAM: ☐ Stated why? YES NO NA
26) Desired precision for GAM: ☐ Stated why? YES NO NA
27) Expected CMR: ☐ Stated why? YES NO NA
28) Expected Deff for CMR: ☐ Stated why? YES NO NA
29) Desired precision for CMR: ☐ Stated why? YES NO NA

Nutrition survey
30-35 only if nutrition module included, otherwise ↳ 36
30) GAM includes bilateral oedema YES NO
31) Children from 6-59cm or 65-110cm YES NO
32) Weight rounded to 100g YES NO
33) Height rounded to 1mm YES NO
34) Children < 87cm measured lying down YES NO
35) Questionnaire is provided in Appendix YES NO

Methods (Ctd)

Mortality survey
36-39 only if mortality module included, ↳ otherwise 40
36) Recall period stated YES NO
37) Denominator calculation indicated YES NO
38) Census method indicated YES NO
39) Questionnaire is provided in Appendix YES NO

Results

Analysis
40) Software and statistical procedure stated YES NO

Nutritional Indicators
41-50 only if nutrition module included, otherwise ↳ 51
Definition:
41) GAM is expressed in Z-score (or % median) YES NO
42) Weight-for-Height Index YES NO
43) WHO reference (NCHS) is stated YES NO
Precision:
44) Confidence interval [____ ; ____]
45) 95% CI adjusted by design effect YES NO NA
46) Design effect: ☐
47) Outliers are accounted for YES NO NA
48) Plausibility checks mentioned YES NO
49) Definition of flags stated YES NO
50) Sample size of 6-59 months: ☐

Mortality indicators
51-61 only if mortality module included, otherwise ↳ 62
51) CMR expressed as death per 10,000/day, 1,000/month or 1,000/year YES NO
Precision:
52) Confidence interval [____ ; ____]
53) 95% CI adjusted by design effect YES NO NA
54) Design effect: ☐

Demographic indicators
55) Births: ☐ 57) Deaths: ☐
56) Persons joined: ☐ 58) Pers. left: ☐
59) Population at the time of the survey: ☐
60) n° of households: ☐
61) n° of U5 (0-59 months): ☐

Vaccination indicators
62-64 only if vaccination module included, otherwise ↳ 65
62) MCV coverage by card and history YES NO
63) Confidence interval [____ ; ____]
64) n° of children 9-59 months: ☐

Discussion

Limitation and bias
66-67 only if cluster sampling, ↳ 68 only if replacement was made, otherwise ↳ 69
65) % non response: ☐
66) % inaccessible clusters: ☐
67) Final number of clusters: ☐
68) Replacement method stated? YES NO NA
69) Potential bias described? YES NO

Comparison of results
Interpretation of results
70) Results are compared to a reference YES NO
71) Recommendations are given YES NO

CE-DAT Completeness Checklist

Appendix B

Details of the 231 Small-scale Surveys Used in Chapter 3

Survey ID	Survey area (Admin 1-Admin 2-Admin 3)	Month-Year	Wasted (%)	Sample size	Drought episode	Conflict status
AF12	Afar - Zone 2 - Megale	05 - 2013	11.4	599	No	No
AF13	Afar - Zone 2 - Koneba	04 - 2013	11.7	555	Mild	No
AF14	Afar - Zone 4 - Gulina	05 - 2013	11.3	513	Severe	No
AM50	Amhara - North Wollo - Meket	04 - 2013	9.8	632	Mild	No
OR69	Oromia - East Harerghe - Fedis	10 - 2013	8.0	725	No	No
OR70	Oromia - East Harerghe - Deder	09 - 2013	8.0	701	No	No
OR71	Oromia - West Harerghe - Anchar	09 - 2013	10.4	693	No	No
OR72	Oromia - West Harerghe - Darolebu	04 - 2013	6.4	624	Mild	Yes
OR73	Oromia - East Harerghe - Meta	11 - 2013	5.8	626	Mild	No
OR74	Oromia - Borena - Bulehora	03 - 2013	3.3	522	Mild	No
OR75	Oromia - West Harerghe - Oda Bultum	03 - 2013	4.9	534	Mild	No
SN66	SNNP - Wolayita - Damot Pulassa	02 - 2013	4.1	438	Mild	No
SO21	Somali - Jijiga - Harshin	05 - 2013	15.7	615	No	No
SO22	Somali - Liben - Dollo Ado	08 - 2013	18.3	789	Severe	Yes
AM49	Amhara - South Wollo - Dessie Zuria	03 - 2012	13.6	456	No	No
OR66	Oromia - West Harerghe - Oda Bultum	03 - 2012	4.8	500	Mild	No
OR67	Oromia - Borena - Bulehora	02 - 2012	5.0	640	Mild	No
OR68	Oromia - Borena - Abaya	02 - 2012	5.6	549	Mild	No
SN64	SNNP - Wolayita - Damot Pulassa	09 - 2012	4.1	511	Mild	No
SN65	SNNP - Sidama - Boricha	05 - 2012	8.2	661	Moderate	No
AM45	Amhara - North Wollo - Habru	01 - 2011	4.9	575	Severe	No
AM46	Amhara - North Gondar - East Belesa	04 - 2011	13.8	623	No	No
AM47	Amhara - Wag Hamra - Sekora	03 - 2011	14.5	609	Mild	No

AM48	Amhara - North Gondar - Wegera	12 - 2011	10.6	604	No	No
DD02	Dire Dawa - NA - Rural kebeles	05 - 2011	12.0	526	Severe	Yes
OR56	Oromia - East Harerghe - Deder	09 - 2011	5.2	639	No	No
OR57	Oromia - East Harerghe - Kurkfa Chelle	01 - 2011	8.8	506	No	No
OR58	Oromia - East Harerghe - Midega Tola	01 - 2011	11.9	536	No	No
OR59	Oromia - West Harerghe - Oda Bultum	03 - 2011	12.6	558	Mild	No
OR60	Oromia - Guji - Liben	06 - 2011	14.4	866	Mild	No
OR61	Oromia - West Harerghe - Habroo	02 - 2011	10.2	459	Mild	No
OR62	Oromia - West Harerghe - Boke	01 - 2011	6.7	650	Mild	No
OR63	Oromia - Borena - Bulehora	02 - 2011	12.3	765	Severe	No
OR64	Oromia - East Harerghe - Meta	10 - 2011	10.5	666	Severe	Yes
OR65	Oromia - East Harerghe - Melkabello	12 - 2011	9.3	614	No	No
AM34	Amhara - North Gondar - East Belesa	04 - 2010	18.8	672	No	No
AM35	Amhara - North Wollo - Bugna	10 - 2010	14.6	480	Mild	No
AM36	Amhara - North Gondar - Wegera	11 - 2010	13.4	521	Mild	No
AM37	Amhara - North Wollo - Lasta	04 - 2010	13.0	641	No	No
AM38	Amhara - South Wollo - Mekdela	06 - 2010	15.7	561	No	No
AM39	Amhara - South Wollo - Dessie Zuria	07 - 2010	11.9	457	No	No
AM40	Amhara - South Wollo - Dessie Zuria	04 - 2010	11.3	524	No	No
AM41	Amhara - South Wollo - Delanta	08 - 2010	11.1	657	No	No
AM42	Amhara - Wag Hamra - Abergele	12 - 2010	11.9	542	Mild	No
AM43	Amhara - South Wollo - Tenta	04 - 2010	7.4	774	No	No
AM44	Amhara - South Wollo - Ambasel	02 - 2010	8.6	547	Mild	No
BG01	Benishangul-Gumuz - Asosa - Kurmuk	12 - 2010	17.1	520	Moderate	No
BG02	Benishangul-Gumuz - Asosa - Bambasi	11 - 2010	12.5	590	Severe	No
DD01	Dire Dawa - NA - Rural kebeles	08 - 2010	13.1	510	Mild	Yes

OR44	Oromia - Bale - Mena Angetu	02 - 2010	17.7	654	No	No
OR45	Oromia - West Harerghe - Miesso	04 - 2010	12.5	694	Mild	No
OR46	Oromia - East Harerghe - Melkabello	11 - 2010	9.5	610	No	No
OR47	Oromia - Borena - Abaya	02 - 2010	10.1	737	No	No
OR48	Oromia - West Harerghe - Boke	01 - 2010	15.4	674	Mild	No
OR49	Oromia - East Harerghe - Kersa	03 - 2010	7.6	709	No	No
OR50	Oromia - West Harerghe - Habroo	02 - 2010	10.4	644	No	No
OR51	Oromia - West Harerghe - Darolebu	10 - 2010	5.5	553	No	No
OR52	Oromia - East Harerghe - Meta	10 - 2010	9.7	679	No	No
OR53	Oromia - East Harerghe - Meta	02 - 2010	10.7	721	Mild	No
OR54	Oromia - Bale - Mena Angetu	07 - 2010	5.5	657	No	No
OR55	Oromia - Borena - Gelana	12 - 2010	5.7	577	Mild	No
SN58	SNNP - Wolayita - Damot Woyed, Dugna Fango	02 - 2010	6.1	929	No	No
SN59	SNNP - Wolayita - Offa	02 - 2010	6.0	654	No	No
SN60	SNNP - Wolayita - Damot Gale	03 - 2010	4.9	702	No	No
SN61	SNNP - Sidama - Boricha	06 - 2010	5.5	508	Mild	No
SN62	SNNP - Sidama - Shebdino	03 - 2010	9.9	699	No	No
SN63	SNNP - Wolayita - Damot Pulassa	06 - 2010	5.1	545	Mild	No
AM28	Amhara - South Wollo - Mekdela	06 - 2009	13.2	567	Severe	No
AM29	Amhara - South Wollo - Ambasel	03 - 2009	11.1	434	Mild	No
AM30	Amhara - South Wollo - Ambasel	08 - 2009	12.5	609	Mild	No
AM31	Amhara - South Wollo - Dessie Zuria	09 - 2009	14.2	451	Mild	Yes
AM32	Amhara - North Wollo - Gubalafto	06 - 2009	8.4	678	Severe	No
AM33	Amhara - South Wollo - Wara Babo	09 - 2009	11.1	651	Mild	Yes
OR30	Oromia - West Harerghe - Hawigudina	07 - 2009	12.3	709	Mild	No
OR31	Oromia - West Harerghe - Kuni	03 - 2009	9.6	641	No	No

OR32	Oromia - West Harerghe - Burka Dintu	07 - 2009	14.4	730	Moderate	No
OR33	Oromia - West Harerghe - Boke	07 - 2009	14.8	691	Moderate	No
OR34	Oromia - East Harerghe - Kombolcha	03 - 2009	12.6	685	Mild	No
OR35	Oromia - East Harerghe - Kersa	03 - 2009	14.8	678	No	No
OR36	Oromia - East Harerghe - Deder	09 - 2009	10.6	678	Moderate	No
OR37	Oromia - Borena - Abaya	08 - 2009	12.6	794	Mild	No
OR38	Oromia - West Harerghe - Darolebu	10 - 2009	12.0	744	Mild	Yes
OR39	Oromia - East Harerghe - Meta	09 - 2009	11.4	683	Moderate	No
OR40	Oromia - East Harerghe - Melkabello	10 - 2009	15.2	666	Moderate	Yes
OR41	Oromia - East Harerghe - Goro Gutu	11 - 2009	7.5	676	Moderate	No
OR42	Oromia - Borena - Gelana	11 - 2009	14.1	839	Moderate	No
OR43	Oromia - East Harerghe - Fedis	12 - 2009	10.9	768	Moderate	No
SN46	SNNP - Sidama - Boricha	04 - 2009	11.2	658	Mild	No
SN47	SNNP - Wolayita - Damot Pulassa	04 - 2009	12.9	680	Mild	No
SN48	SNNP - Wolayita - Damot Gale	03 - 2009	7.4	876	No	No
SN49	SNNP - Gedeo - Gedeb	02 - 2009	9.3	772	No	No
SN50	SNNP - Gedeo - Bule	02 - 2009	7.4	876	No	No
SN51	SNNP - Gamogofa - Arba Minch Zuria	01 - 2009	1.4	702	No	No
SN52	SNNP - Sidama - Shebdino	03 - 2009	17.5	635	No	No
SN53	SNNP - Gedeo - Gedeb	09 - 2009	6.2	617	Moderate	No
SN54	SNNP - Gedeo - Bule	09 - 2009	4.4	589	Moderate	No
SN55	SNNP - Hadiya - Soro	01 - 2009	14.3	523	No	No
SN56	SNNP - Hadiya - Shashago	01 - 2009	8.3	591	No	No
SN57	SNNP - Wolayita - Bolosso Sorie	12 - 2009	5.7	673	Mild	No
AM26	Amhara - South Wollo - Dessie Zuria	05 - 2008	13.3	616	Moderate	No
AM27	Amhara - South Wollo - Mekdela	11 - 2008	12.8	686	Mild	No

OR27	Oromia - West Harerghe - Darolebu	01 - 2008	9.1	497	No	No
OR28	Oromia - West Harerghe - Kuni	09 - 2008	12.4	766	No	Yes
OR29	Oromia - East Harerghe - Kersa	06 - 2008	13.0	539	No	Yes
SN37	SNNP - Wolayita - Offa	04 - 2008	10.1	763	Mild	No
SN38	SNNP - Wolayita - Damot Woyed, Dugna Fango	03 - 2008	14.4	767	Mild	No
SN39	SNNP - Wolayita - Damot Pulassa	04 - 2008	17.8	658	Mild	No
SN40	SNNP - Sidama - Boricha	04 - 2008	20.3	656	Mild	No
SN41	SNNP - Wolayita - Damot Gale	07 - 2008	13.0	777	No	No
SN42	SNNP - Hadiya - Soro	09 - 2008	11.3	609	No	No
SN43	SNNP - Gurahe - Mareko	10 - 2008	7.3	656	No	No
SN44	SNNP - Wolayita - Damot Gale	12 - 2008	5.2	695	No	No
SN45	SNNP - Wolayita - Damot Pulassa	12 - 2008	5.1	551	No	No
AF11	Afar - Zone 3 - Gewane	10 - 2007	22.6	570	Mild	No
AM22	Amhara - South Wollo - Dessie Zuria	01 - 2007	18.3	717	No	No
AM23	Amhara - South Wollo - Kalu	01 - 2007	9.3	881	No	No
AM24	Amhara - South Wollo - Kalu	08 - 2007	11.4	544	Mild	No
AM25	Amhara - South Wollo - Dessie Zuria	09 - 2007	13.8	645	Mild	No
OR25	Oromia - East Harerghe - Fedis	02 - 2007	8.4	787	No	Yes
OR26	Oromia - West Harerghe - Darolebu	08 - 2007	10.3	719	No	No
SN31	SNNP - Sidama - Bona	05 - 2007	18.5	720	Mild	No
SN32	SNNP - Silti - Silti	03 - 2007	10.6	763	Mild	No
SN33	SNNP - Wolayita - Offa	06 - 2007	1.6	442	No	No
SN34	SNNP - Wolayita - Dugna Fango	06 - 2007	2.9	543	No	No
SN35	SNNP - Wolayita - Damot Woyde	06 - 2007	2.9	541	No	Yes
SN36	SNNP - Silti - Silti	08 - 2007	3.9	606	Mild	No
AF08	Afar - Zone 4 - Yalo	03 - 2006	13.0	940	Mild	No

AF09	Afar - Zone 4 - Yalo	11 - 2006	13.2	995	No	No
AF10	Afar - Zone 4 - Teru	11 - 2006	11.0	996	No	No
AM18	Amhara - South Wollo - Dessie Zuria	08 - 2006	14.3	687	No	No
AM19	Amhara - South Wollo - Kalu	07 - 2006	12.0	824	No	No
AM20	Amhara - South Wollo - Kalu	01 - 2006	9.8	905	Mild	Yes
AM21	Amhara - South Wollo - Dessie Zuria	01 - 2006	14.3	912	Mild	No
OR19	Oromia - Borena - Dire	01 - 2006	11.8	902	Mild	Yes
OR20	Oromia - Borena - Moyale	01 - 2006	12.7	903	Mild	No
OR21	Oromia - Borena - Teltele	01 - 2006	7.5	914	Severe	No
OR22	Oromia - East Harerghe - Kombolcha	04 - 2006	7.7	980	Mild	Yes
OR23	Oromia - Bale - Goro	02 - 2006	7.5	903	Mild	No
OR24	Oromia - East Harerghe - Deder	06 - 2006	11.1	970	No	No
SN29	SNNP - Wolayita - Offa	06 - 2006	4.6	812	No	No
SN30	SNNP - Wolayita - Damot Woyde	06 - 2006	4.9	807	No	No
SO16	Somali - Afder - Dollo Addo and Dollo Bay	01 - 2006	22.2	906	Mild	No
SO17	Somali - Deghabur - Degehabur	02 - 2006	22.3	797	Mild	No
SO18	Somali - Gode - East Imey	02 - 2006	23.8	933	No	No
SO19	Somali - Afder - Dollo Addo and Dollo Bay	02 - 2006	20.8	906	Mild	No
SO20	Somali - Gode - Denan	01 - 2006	25.6	935	Mild	No
AF05	Afar - Zone 2 - Abe-Ala	10 - 2005	15.6	964	No	No
AF06	Afar - Zone 2 - Berahile	10 - 2005	21.1	963	No	No
AF07	Afar - Zone 2 - Abe-Ala	02 - 2005	15.5	966	Mild	No
AM15	Amhara - Wag Hamra - Dehana	06 - 2005	18.2	900	No	No
AM16	Amhara - Wag Hamra - Sekora	06 - 2005	16.8	896	No	No
AM17	Amhara - South Wollo - Kalu	07 - 2005	13.9	905	No	Yes
OR16	Oromia - West Harerghe - Kuni	06 - 2005	7.5	961	No	No

OR17	Oromia - West Harerghe - Kuni	12 - 2005	9.1	968	Mild	No
OR18	Oromia - East Harerghe - Fedis	12 - 2005	8.4	968	Mild	Yes
SN22	SNNP - Sidama - Dale	06 - 2005	18.0	962	No	No
SN23	SNNP - Sidama - Awassa	09 - 2005	5.8	965	No	No
SN24	SNNP - Sidama - Dale	12 - 2005	6.6	976	Mild	No
SN25	SNNP - GAMOGOFA - Gofa Zuria	05 - 2005	3.4	960	No	No
SN26	SNNP - Sidama - Shebdino	05 - 2005	17.9	960	No	No
SN27	SNNP - Wolayita - Offa	12 - 2005	5.9	935	No	No
SN28	SNNP - Wolayita - Damot Woyde	11 - 2005	5.1	915	No	No
SO14	Somali - Fik - Hamero and Fik	05 - 2005	18.2	900	Mild	No
SO15	Somali - Deghabur - Misraq Gashamo	01 - 2005	21.8	974	No	No
AF03	Afar - Zone 5 - Semu Robi	12 - 2004	10.9	880	Mild	No
AF04	Afar - Zone 1 - Assayita	12 - 2004	13.4	910	No	No
OR15	Oromia-East Harerghe-Kersa, Meta	01 - 2004	5.2	901	Mild	No
SN21	SNNP - Sidama - Shebdino	02 - 2004	9.4	1033	No	No
SO10	Somali - Afder and Liben - Cherati, Dollo Addo, Dollo Bay, West-Emey	10 - 2004	19.8	900	No	Yes
SO11	Somali-Shinilie-Shinele, Dembel, Erer	08 - 2004	9.7	891	Mild	No
SO12	Somali - Shinilie - Ayshia, Dembel, Erer, Shinile	08 - 2004	11.6	912	Mild	Yes
SO13	Somali - Gode - Godie	02 - 2004	23.5	925	Mild	Yes
AF02	Afar - Zone 3 - Rural areas	04 - 2003	13.5	900	Mild	No
AM09	Amhara - North Wollo - Gubalafto	06 - 2003	4.9	902	Mild	No
AM10	Amhara - South Wollo - Kalu	07 - 2003	10.1	1227	Mild	No
AM11	Amhara - South Wollo - Kalu	03 - 2003	10.9	930	No	No
AM12	Amhara-South Wollo-Dessie Zuria	07 - 2003	13.6	1113	Mild	No
AM13	Amhara-South Wollo-Dessie Zuria	11 - 2003	13.9	936	No	No

AM14	Amhara - South Wollo - Kalu	11 - 2003	11.7	1052	No	No
OR08	Oromia-East Shewa-Adami Tullu Jido	10 - 2003	8.6	905	No	No
OR09	Oromia - West Harerghe - Rural lowland and dry mid-lands	06 - 2003	11.9	924	Mild	No
OR10	Oromia - East Shewa - Ziway, Adami Tullu, Jido	06 - 2003	19.2	909	No	No
OR11	Oromia - West Harerghe - Darolebu	06 - 2003	6.4	910	No	No
OR12	Oromia - East Harerghe - Kurkfa Chelle, Grawa, Bedeno, Mayu	05 - 2003	16.9	910	Mild	Yes
OR13	Oromia - West Arsi - Siraro	06 - 2003	9.0	871	No	No
OR14	Oromia - East Harerghe - Golo Odana Meyumuluke	12 - 2003	7.7	915	Mild	No
SN12	SNNP - Sidama - Boricha	10 - 2003	5.2	956	Mild	No
SN13	SNNP - Sidama - Dale	10 - 2003	9.5	900	Mild	No
SN14	SNNP - Wolayita - Offa	09 - 2003	21.5	905	Mild	No
SN15	SNNP - Wolayita - Offa	05 - 2003	18.8	881	No	No
SN16	SNNP - Wolayita - Offa	12 - 2003	15.4	910	Mild	No
SN17	SNNP - Silti - Dalocha	12 - 2003	7.5	904	Mild	No
SN18	SNNP - Silti - Lanfuro	12 - 2003	11.5	907	Mild	No
SN19	SNNP - Gurahe - Meskan	11 - 2003	10.8	942	No	No
SN20	SNNP - Gurahe - Mareko	11 - 2003	14.8	903	No	No
SO06	Somali - Fik - Fik and Hamero	04 - 2003	35.7	913	Moderate	No
SO07	Somali - Fik - Segeg, Duhun, Gerbo	04 - 2003	33.1	910	Moderate	No
SO08	Somali-Shinilie-Ayshia, Dembel, Erer	10 - 2003	13.1	898	Mild	No
SO09	Somali-Shinilie-Ayshia, Dembel, Erer	10 - 2003	13.0	893	Mild	No
AF01	Afar - Zone 3 - Rural pastorals	08 - 2002	20.0	900	Mild	Yes
AM05	Amhara-North Gondar-West Belessa	07 - 2002	15.0	902	Mild	No
AM06	Amhara-South Wollo-Dessie Zuria	12 - 2002	19.3	905	Mild	No

AM07	Amhara - South Wollo - Kalu	11 - 2002	18.7	909	Mild	No
AM08	Amhara - South Wollo - Kalu	01 - 2002	11.5	903	Mild	No
OR06	Oromia - Borena - Moyale	03 - 2002	8.3	907	Mild	Yes
OR07	Oromia - East Harerghe - Golo Oda, Meyu Muluke	10 - 2002	17.0	902	Mild	No
SN08	SNNP - Wolayita - Lowland areas	01 - 2002	5.6	901	No	No
SN09	SNNP - Wolayita - Highland areas	01 - 2002	5.5	906	No	No
SN10	SNNP - KAT - Alaba Special	08 - 2002	7.6	902	Moderate	No
SN11	SNNP - Hadiya - Badawocho, Soro	08 - 2002	12.1	904	Moderate	No
SO05	Somali - Liben - Moyale	03 - 2002	19.2	908	Mild	No
AM02	Amhara - South Wollo - Legambo	02 - 2001	11.6	914	No	No
AM03	Amhara - South Wollo - Kalu	02 - 2001	15.8	907	No	No
AM04	Amhara-East Gojam-Goncha Siso Enebse	06 - 2001	10.2	905	No	No
OR04	Oromia - Borena - Yabello, Teltele	03 - 2001	5.8	954	No	No
OR05	Oromia - East Harerghe - Golo Odana Meyumuluke	03 - 2001	21.5	926	No	Yes
SN07	SNNP - Wolayita - Damot Woyde	04 - 2001	3.7	906	Mild	No
AM01	Amhara - South Wollo - Kalu	10 - 2000	12.6	910	No	No
OR01	Oromia - Borena - Arero	07 - 2000	15.9	901	Mild	No
OR02	Oromia - Borena - Arero	10 - 2000	12.4	959	Mild	Yes
OR03	Oromia - Borena -	12 - 2000	7.3	957	Mild	No
SN01	SNNP - Wolayita - Damot Woyde	10 - 2000	8.7	903	No	No
SN02	SNNP - Konso Liyu - Konso Special	08 - 2000	12.7	907	Mild	No
SN03	SNNP - Wolayita - Bolosso Sorie	11 - 2000	9.0	1031	Mild	No
SN04	SNNP - Wolayita - Offa	10 - 2000	21.7	882	No	No
SN05	SNNP - Wolayita - Damot Woyde	03 - 2000	27.6	960	Moderate	No
SN06	SNNP - Wolayita - Bolosso Sorie	06 - 2000	46.1	908	Mild	No
SO01	Somali - Fik - Fik	07 - 2000	26.1	514	Mild	No

SO02	Somali - Fik - Hamero	07 - 2000	34.1	300	Mild	No
SO03	Somali - Fik - Duhun	07 - 2000	41.5	358	Mild	No
SO04	Somali - Fik - Segeg, Duhun	11 - 2000	26.2	914	Mild	No

Wasting was defined as weight-for-height z-scores below -2, standardized to WHO reference [92]. Conflict events were occurrence of conflict in a given location within six months of the survey starting date. Data from the Armed Conflict Location and Event Dataset [103] and the Uppsala Conflict Data Program Armed Conflict Dataset [104] were combined into a binary variable. Drought episodes in a given location were based on the three-month standardized precipitation evapotranspiration index (SPEI) from the Global Drought Monitor database [98], and categorize according to [136]: no drought ($SPEI > 0$), mild drought ($-1 < SPEI \leq 0$), moderate drought ($-1.5 < SPEI \leq -1$) and severe to extreme drought (severe drought hereafter) ($SPEI \leq -1.5$)

Appendix C

Details of the 88 Small-scale Surveys Used in Chapter 4

Survey ID	Survey area (admin1-admin2-admin3)	Month-Year	No. of U5 deaths	No. of children	Short-term drought	Long-term drought	GAM (%)	MCV (%)	Food insecurity	Livelihood zones
AM01	Amhara-South Wollo-Ambasel	03 - 2009	2	288	moderate	moderate	11.1	87.5	crisis	cropping
AM02	Amhara-South Wollo-Ambasel	08 - 2009	0	347	normal	moderate	12.5	82.2	crisis	cropping
AM03	Amhara - South Wollo - Dessie Zuria	09 - 2009	2	239	mild	moderate	14.2	83.4	crisis	cropping
AM04	Amhara-North Wollo-Gubalafto	06 - 2009	1	292	severe	moderate	8.4	78.9	crisis	cropping
AM05	Amhara - South Wollo - Wara Babo	09 - 2009	5	422	mild	moderate	11.1	83.6	crisis	cropping
OR01	Oromia - West Harerghe - Boke	03 - 2009	7	780	mild	moderate	14.8	32.6	crisis	agropastoral
OR02	Oromia - West Harerghe - Burka Dintu	07 - 2009	8	820	moderate	moderate	14.4	18.5	crisis	agropastoral
OR03	Oromia - East Harerghe - Deder	09 - 2009	1	766	moderate	moderate	10.6	54.7	crisis	cropping
OR04	Oromia - East Harerghe - Goro Gutu	11 - 2009	1	764	mild	severe	7.5	61.0	crisis	cropping
OR05	Oromia - West Harerghe - Hawigudina	07 - 2009	2	802	mild	mild	12.3	24.4	NA	agropastoral
OR06	Oromia - East Harerghe - Kersa	03 - 2009	2	678	mild	normal	14.8	64.2	crisis	cropping
OR07	Oromia - East Harerghe - Meta	09 - 2009	2	764	severe	severe	11.4	61.9	crisis	cropping
SN01	SNNP - Gamo Gofa - Arba Minch Zuria	01 - 2009	0	702	normal	normal	1.4	92.8	NA	cropping
SN02	SNNP - Sidama - Boricha	04 - 2009	5	706	moderate	mild	11.2	68.1	crisis	cropping
SN03	SNNP - Gedeo - Bule	02 - 2009	2	996	mild	normal	7.4	62.1	NA	cropping
SN04	SNNP - Gedeo - Bule	09 - 2009	3	655	severe	moderate	4.4	27.2	crisis	cropping
SN05	SNNP - Wolayita - Damot Gale	03 - 2009	8	733	mild	normal	9.9	64.2	NA	cropping
SN06	SNNP - Gedeo - Gedeb	09 - 2009	2	700	severe	moderate	6.2	40.3	crisis	cropping
SN07	SNNP - Hadiya - Shashago	01 - 2009	1	591	normal	normal	8.3	10.2	NA	cropping

SN08	SNNP - Sidama - Shebdino	03 - 2009	3	766	mild	normal	17.5	68.9	stressed	cropping
SN09	SNNP - Hadiya - Soro	01 - 2009	4	524	normal	normal	14.3	64.3	NA	cropping
AM06	Amhara - Wag Hamra - Abergele	12 - 2010	2	542	severe	moderate	11.9	75.8	crisis	cropping
AM07	Amhara - South Wollo - Ambasel	02 - 2010	0	256	normal	mild	8.6	87.5	crisis	cropping
AM08	Amhara - North Wollo - Bugna Woreda	10 - 2010	1	480	mild	mild	14.6	82.2	crisis	cropping
AM09	Amhara - South Wollo - Dessie Zuria	04 - 2010	2	465	normal	normal	11.3	83.5	crisis	cropping
AM10	Amhara - South Wollo - Dessie Zuria	07 - 2010	0	257	normal	normal	11.9	87.1	stressed	cropping
AM11	Amhara - North Gondar - East Belesa	04 - 2010	3	672	normal	mild	18.8	52.1	crisis	cropping
AM12	Amhara - North Wollo - Lasta Woreda	04 - 2010	5	641	normal	moderate	13	85.9	stressed	cropping
AM13	Amhara - South Wollo - Mekdela	06 - 2010	2	561	mild	moderate	15.7	77.2	stressed	cropping
AM14	Amhara - North Gondar - Wegera Woreda	11 - 2010	0	521	mild	mild	13.4	76.4	crisis	cropping
AM15	Amhara - North Wollo - Delenta	08 - 2010	2	366	normal	normal	11.1	89.3	stressed	cropping
AM16	Amhara - South Wollo - Tenta	04 - 2010	1	859	normal	normal	7.4	88.7	crisis	cropping
BG01	Benishangul-Gumuz - Bambasi	11 - 2010	4	590	severe	severe	12.5	78.5	minimal	cropping
BG02	Benishangul-Gumuz - Kurmuk	12 - 2010	3	520	severe	severe	17.1	83.8	stressed	cropping
DD01	Dire Dawa - Dire Dawa - Dire Dawa zuriya	08 - 2010	1	510	normal	mild	13.1	65.0	NA	agropastoral
OR08	Oromia - West Harerghe - Darolebu	10 - 2010	2	553	normal	normal	5.5	67.1	crisis	agropastoral
OR09	Oromia - Borena - Gelana	12 - 2010	0	577	mild	mild	5.7	69.2	crisis	agropastoral
OR10	Oromia - East Harerghe - Kersa	03 - 2010	1	709	normal	normal	7.6	50.2	stressed	cropping
OR11	Oromia - East Harerghe - Melkabello	11 - 2010	1	610	normal	normal	9.5	66.9	crisis	cropping

OR12	Oromia - Bale - Mena Angetu	02 - 2010	6	731	normal	moderate	17.7	44.3	stressed	cropping
OR13	Oromia - Bale - Mena Angetu	07 - 2010	5	794	normal	normal	5.5	54.6	stressed	cropping
OR14	Oromia - East Harerghe - Meta	02 - 2010	4	721	mild	severe	10.7	77.3	stressed	cropping
OR15	Oromia - East Harerghe - Meta	10 - 2010	1	679	normal	mild	9.7	71.7	crisis	cropping
OR16	Oromia - Borena - Abaya	02 - 2010	2	737	normal	moderate	10.1	35.8	stressed	agropastoral
OR17	Oromia - West Harerghe - Boke	01 - 2010	2	674	mild	moderate	15.4	44.0	stressed	agropastoral
OR18	Oromia - West Harerghe - Habroo	02 - 2010	0	644	normal	mild	10.4	44.4	stressed	cropping
SN10	SNNP - Sidama - Boricha	06 - 2010	1	508	severe	severe	5.5	79.1	crisis	cropping
SN11	SNNP - Wolayita - Damot Gale	03 - 2010	0	702	normal	mild	4.9	71.4	stressed	cropping
SN12	SNNP - Wolayita - Damot Pulassa	06 - 2010	2	545	mild	mild	5.1	82.2	stressed	cropping
SN13	SNNP - Wolayita - Offa	02 - 2010	4	622	normal	mild	8.2	47.0	stressed	cropping
SN14	SNNP - Sidama - Shebdino	03 - 2010	2	699	normal	mild	9.9	77.5	stressed	cropping
SN15	SNNP - Wolayita - Humbo	04 - 2010	3	933	mild	mild	4.0	91.0	crisis	cropping
AM17	Amhara - North Gondar - East Belesa	04 - 2011	1	697	normal	mild	13.8	72.1	crisis	cropping
AM18	Amhara - North Wollo - Habru Woreda	01 - 2011	2	716	severe	severe	4.9	73.6	stressed	cropping
AM19	Amhara - Wag Hamra - Sekora	03 - 2011	0	609	normal	mild	14.5	80.7	stressed	cropping
AM20	Amhara - North Gondar - Wegera Woreda	12 - 2011	1	690	mild	mild	10.6	11.9	stressed	cropping
DD02	Dire Dawa - Dire Dawa - Dire Dawa zuriya	05 - 2011	4	583	severe	severe	12.0	57.4	stressed	agropastoral
OR19	Oromia - West Harerghe - Boke	01 - 2011	2	650	moderate	normal	6.7	82.8	crisis	agropastoral
OR20	Oromia - Borena - Bule Hora	02 - 2011	1	765	moderate	severe	12.3	36.7	stressed	agropastoral
OR21	Oromia - West Harerghe - Habroo	02 - 2011	0	460	mild	normal	10.2	66.4	stressed	cropping

OR22	Oromia - East Harerghe - Kurkfa Chelle	01 - 2011	2	506	normal	normal	8.8	79.6	stressed	cropping
OR23	Oromia - Guji - Liben	04 - 2011	2	1007	severe	severe	14.4	78.3	crisis	agropastoral
OR24	Oromia - East Harerghe - Melka-bello	12 - 2011	1	629	normal	normal	9.3	86.6	stressed	cropping
OR25	Oromia - East Harerghe - Meta	10 - 2011	0	754	mild	severe	10.5	8.2	stressed	cropping
OR26	Oromia - East Harerghe - Midega Tola	01 - 2011	2	536	normal	normal	11.9	56.7	crisis	cropping
OR27	Oromia - West Harerghe - Oda Bultum	03 - 2011	1	558	mild	mild	12.6	61.7	stressed	cropping
AM21	Amhara - South Wollo - Dessie Zuria	03 - 2012	1	490	normal	normal	13.6	81.5	stressed	cropping
AM22	Amhara - Wag Hamra - Ziquala	09 - 2012	6	709	normal	normal	13.7	67.7	crisis	cropping
OR28	Oromia - Borena - Abaya	02 - 2012	0	622	mild	moderate	5.6	6.1	minimal	agropastoral
OR29	Oromia - Borena - Bule Hora	02 - 2012	0	710	moderate	severe	5.0	2.1	crisis	agropastoral
OR30	Oromia - West Harerghe - Oda Bultum	03 - 2012	0	567	moderate	mild	4.8	11.6	stressed	cropping
SN16	SNNP - Sidama - Boricha	05 - 2012	2	748	moderate	moderate	8.2	5.8	stressed	cropping
SN17	SNNP - Wolayita - Damot Pullasa	09 - 2012	3	538	normal	mild	4.1	93.3	crisis	cropping
AF01	Afar - Afar Zone 4 - Gulina	05 - 2013	4	589	severe	severe	11.3	8.1	stressed	pastoral
AF02	Afar - Afar Zone 2 - Koneba	04 - 2013	4	625	normal	normal	11.7	28.5	crisis	agropastoral
AF03	Afar - Afar Zone 2 - Megale	05 - 2013	3	664	mild	mild	11.4	31.9	crisis	pastoral
OR31	Oromia - West Harerghe - Anchar	09 - 2013	1	769	normal	normal	10.4	63.0	crisis	agropastoral
OR32	Oromia - Borena - Bulehora	03 - 2013	2	661	moderate	severe	3.3	54.0	stressed	agropastoral
OR33	Oromia - West Harerghe - Darolebu	04 - 2013	0	698	mild	mild	6.4	60.1	crisis	agropastoral
OR34	Oromia - East Harerghe - Deder	09 - 2013	1	802	normal	normal	8.0	67.5	stressed	cropping
OR35	Oromia - East Harerghe - Fedis	10 - 2013	1	794	normal	normal	8.0	91.4	stressed	cropping

OR36	Oromia - East Harerghe - Meta	11 - 2013	1	687	mild	severe	5.8	81.9	stressed	cropping
OR37	Oromia - West Harerghe - Oda Bultum	03 - 2013	0	606	mild	mild	4.9	60.2	crisis	cropping
SN18	SNNP - Wolayita - Damot Pulassa	02 - 2013	1	476	mild	mild	4.1	79.3	stressed	cropping
AF04	Afar - Afar Zone 2 - Afdera	04 - 2014	4	575	normal	normal	27.0	4.6	crisis	pastoral
AF05	Afar - Afar Zone 4 - Gulina	07 - 2014	1	522	normal	normal	11.6	12.2	stressed	pastoral
GA01	Gambella - Nuer - Jikawo	08 - 2014	14	588	mild	severe	18.4	56.0	minimal	cropping
OR38	Oromia - Borena - Bule Hora	03 - 2014	2	606	normal	normal	5.3	49.0	minimal	agropastoral

The mortality data were obtained from the small-scale retrospective mortality surveys. The short- and long-term droughts in a given location were based on the 3- and 12-month standardized precipitation evapotranspiration index (SPEI), respectively, from the Global Drought Monitor database [98], and then categorised according to [136]: no drought ($SPEI > 0$), mild drought ($-1 < SPEI \leq 0$), moderate drought ($-1.5 < SPEI \leq -1$) and severe to extreme drought (severe drought hereafter) ($SPEI \leq -1.5$). Food insecurity was based on the integrated food security phase classification (IPC). NA: data not available.

Appendix D

Scientific Curriculum Vitae

TEFERA DARGE DELBISO has been working as a research associate at the CRED-Belgium since 2014. Prior to that, he was a research advisor in the non-governmental organization Marie Stops International-Ethiopia, a lecturer at Hawassa University-Ethiopia, and an independent consultant in different organizations. He earned a Bachelor of Science in Statistics and a Master of Science in Population Studies (Reproductive Health) from Addis Ababa University–Ethiopia, and a specialized Master in Public Health Methodology from Université libre de Bruxelles–Belgium. His research activity includes, but not limited to, improving public health needs assessment in humanitarian settings.

Publications

- **Tefera Darge Delbiso**, Chiara Altare, Jose Manuel Rodriguez-Llanes, Shannon Doocy, Debarati Guha-Sapir: *Short and long-term droughts, food security and child mortality in Ethiopia: Can sub-national surveys tell us more about the success of mitigation efforts?* Field Exchange 57/March 2018. https://www.ennonline.net/fex/57/nationalsurveysethiopia

- Joris Adriaan Frank Van Loenhout, **Tefera Darge Delbiso**, Anna Kiriliouk, Jose Manuel Rodriguez-Llanes, Johan Segers, Debarati Guha-Sapir: *Heat and emergency room admissions in the Netherlands.* BMC Public Health 01/2018; 18(108). https://doi.org/10.1186/s12889-017-5021-1

- **Tefera Darge Delbiso**, Chiara Altare, Jose Manuel Rodriguez-Llanes, Shannon Doocy, Debarati Guha-Sapir: *Drought and child mortality: a meta-analysis of small-scale surveys from Ethiopia.* Scientific Reports 2017; 7: 2212. https://www.nature.com/articles/s41598-017-02271-5

- **Tefera Darge Delbiso**, Jose Manuel Rodriguez-Llanes, Anne-Françoise Donneau, Niko Speybroeck, Debarati Guha-Sapir: *Drought, conflict and*

children's undernutrition in Ethiopia 2000–2013: a meta-analysis. Bulletin of the World Health Organisation 02/2017; 95(2). https://doi.org/10.2471/BLT.16.172700

- Joris Adriaan Frank Van Loenhout, **Tefera Darge Delbiso**, Shailvi Gupta, Kapendra Amatya, Adam L. Kushner, Julita Gil Cuesta, Debarati Guha-Sapir: *Barriers to surgical care in Nepal.* BMC Health Services Research 01/2017; 17(1). https://doi.org/10.1186/s12913-017-2024-7

- Lambed Tatah, **Tefera Darge Delbiso**, Jose Manuel Rodriguez-Llanes, Julita Gil Cuesta, Debarati Guha-Sapir: *Impact of Refugees on Local Health Systems: A Difference-in-Differences Analysis in Cameroon.* PLoS ONE 12/2016; 11(12). https://doi.org/10.1371/journal.pone.0168820

- **Tefera Darge Delbiso**, Jose Manuel Rodriguez-Llanes, Chiara Altare, Bruno Masquelier, Debarati Guha-Sapir: *Health at the borders: Bayesian multilevel analysis of women's malnutrition determinants in Ethiopia.* Global Health Action 07/2016; 9. https://doi.org/10.3402/gha.v9.30204

- Surya Gaire, **Tefera Darge Delbiso**, Debarati Guha-Sapir, Srijana Pandey Gaire: *Impact of disasters on child stunting in Nepal.* Risk Management and Healthcare Policy 06/2016; 9(1). https://doi.org/10.2147/RMHP.S101124

- Chiara Altare, **Tefera Darge Delbiso**, George Mutembei Mutwiri, Regine Kopplow, Debarati Guha-Sapir: *Factors Associated with Stunting among Pre-school Children in Southern Highlands of Tanzania.* Journal of Tropical Pediatrics 04/2016; 62(5). https://doi.org/10.1093/tropej/fmw024

- Chiara Altare, **Tefera Darge Delbiso**, Debarati Guha-Sapir: *Child Wasting in Emergency Pockets: A Meta-Analysis of Small-Scale Surveys from Ethiopia.* International Journal of Environmental Research and Public Health 01/2016; 13(2). https://doi.org/10.3390/ijerph13020178

- Shannon Doocy, Emily Lyles, **Tefera Darge Delbiso**, Courtland W. Robinson: *Internal displacement and the Syrian crisis: An analysis of trends from 2011-2014.* Conflict and Health 12/2015; 9(1). https://doi.org/10.1186/s13031-015-0060-7

- Shannon Doocy, **Tefera Darge Delbiso**, The IOCC/GOPA Study Team, Debarati Guha-Sapir: *The Humanitarian Situation in Syria: A Snapshot in the Third Year of the Crisis.* PLoS Currents 03/2015; 7. https://doi.org/10.1371/currents.dis.6b7587562e58cf965bf2d7be36f96de6

Oral Presentations

- **Tefera Darge Delbiso** & Debarati Guha-Sapir: Are droughts bigger drivers of child undernutrition than conflicts in Ethiopia? A meta-analysis of 231 small-scale operational surveys. Presented at the Conference: "Health in Africa – an interdisciplinary approach", 15 December 2017, Ghent, Belgium.

- **Tefera Darge Delbiso**, Chiara Altare, Jose Manuel Rodriguez-Llanes, Shannon Doocy & Debarati Guha-Sapir: Droughts and child mortality: a meta-analysis of operational surveys in Ethiopia. Presented at the Conference: "Research for Nutrition (R4NUT): Operational Challenges and Uptake in Prevention and Treatment of Undernutrition", 13 November 2017, Paris, France.

- **Tefera Darge Delbiso** & Debarati Guha-Sapir: Does humanitarian aid improve child nutrition in Ethiopia? Evidence from small-scale surveys. Presented at the Conference: "Development aid, effectiveness, maternal- and child health, and inequalities in conflict affected societies", 26–27 October 2017, Addis Ababa, Ethiopia.

- **Tefera Darge Delbiso** & Debarati Guha-Sapir: Where do the most disadvantaged children live? The burden of child undernutrition in humanitarian settings in Ethiopia. Presented at the Conference: "Putting Children First: Identifying Solutions and Taking Action to Tackle Child Poverty and Inequality in Africa", 23–25 October 2017, Addis Ababa, Ethiopia.

- **Tefera Darge Delbiso** & Debarati Guha-Sapir: Health at the borders: multilevel analysis of women's malnutrition determinants in Ethiopia. Paper presented at the 9^{th} European Public Health Conference: "All for Health, Health for All", 9–12 November 2016, Vienna, Austria.

- **Tefera Darge Delbiso** & Debarati Guha-Sapir: Drought, conflict and acute malnutrition: Evidence from a Bayesian meta-analysis of 231 small-scale surveys from Ethiopia. Presented at the Conference: "Doctoral Day", 29 September 2016, Brussels, Belgium.