2019

Trends in Prevalence and Predictors of Undernutrition Among Children in South Central

Monica Kabahimba Zikusooka
Walden University

Walden University

College of Health Sciences

This is to certify that the doctoral dissertation by

Monica Kabahimba Zikusooka

has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

Review Committee
Dr. Hebatullah Tawfik, Committee Chairperson, Public Health Faculty
Dr. Joseph Robare, Committee Member, Public Health Faculty
Dr. Simone Salandy, University Reviewer, Public Health Faculty

The Office of the Provost

Walden University
2019

Abstract

Trends in Prevalence and Predictors of Undernutrition Among Children in South Central Somalia

by

Monica Kabahimba Zikusooka

MSC, Makerere University, 2003

BS, Makerere University, 1999

Proposal Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health

Walden University

August 2019

Abstract

Undernutrition is a global public health challenge. In Somalia, undernutrition is chronic with the situation often graded for emergency response. The purpose of this study was to provide contextual evidence regarding trends of prevalence and predictors of undernutrition in South Central Somalia. Following the UNICEF conceptual framework of determinants of undernutrition, the study examined which individual, household, and society factors were associated with undernutrition. Using secondary data from cross-sectional nutritional surveys implemented by the Somalia Food Security and Nutrition Analysis Unit from 2007 to 2012, a sample of 75,756 and 60,856 children aged 6-59 months was used in analyzing trends in prevalence and predictors of undernutrition respectively. Linear regression was used to examine trends, while Generalized Estimation Equations were used to determine predictors of undernutrition. Results of this study showed that from 2007 to 2012, there was a declining trend in the prevalence of stunting ($R^2 = 0.73$; $p < 0.05$) while there was no significant trend in terms of underweight and wasting. When individual, household, and society factors were considered simultaneously, diarrhea, child gender, diet diversity, and minimum meal frequency were significant predictors of underweight; child gender and meal frequency significantly predicted stunting while wasting was significantly predicted by diarrhea, malaria, and diet diversity. Geographical region and livelihood system were significant predictors of undernutrition. The study findings provide evidence to inform nutrition policy and programs that could result in eliminating disparities in child nutrition and reducing undernutrition, ultimately improving survival and development of children in Somalia.

Trends in Prevalence and Predictors of Undernutrition Among Children in South Central Somalia

by

Monica Kabahimba Zikusooka

MSC, Makerere University, 2003

BS, Makerere University, 1999

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health - Epidemiology

Walden University

August 2019

Dedication

This dissertation is dedicated to my husband Jacob. B. Zikusooka, without whom this academic journey would never have started or been completed; and to my daughters, Leesha, Tanya, and Jasmine; to inspire them to dream big, work hard and stay focused.

Acknowledgment

I give thanks to God, for I can do all things through Christ that strengthens me. I would like to immeasurably thank my husband Jacob Zikusooka, for inspiring me to start this journey, for tirelessly cheering me on and for all the sacrifice he made to help me achieve this dream. I thank my daughters Leesha, Tanya, and Jasmine for praying for me, for their understanding when mummy was not available because of school and for allowing me to use a lot of our time together for school work.

I extend my sincere gratitude to my Committee Chair Dr. Hebatullah Tawfik for her leadership, advice, and consistent support throughout the dissertation journey; and my Committee Member Dr. Joseph F. Robare for his advice and contribution to this dissertation. I would also like to thank Dr. Simone W. Salandy, the University Research Reviewer for her in-depth review of my proposal and dissertation report. I am grateful to the Walden Health Sciences faculty team for a rich set of courses and the instructors that facilitated inspiring discussions on various tenets of public health. Finally, I want to thank all my friends that followed my progress, prayed, and encouraged me to keep moving; I finally got to the end.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction to the Study

Introduction

Malnutrition is a public health challenge over which global attention has increased in the post-Millennium Development Goal (MDG) era. In September 2015, the United Nations (UN) adopted Sustainable Development Goals (SDGs) to address poverty, inequality, and climate change challenges for the 21st century. One of the 17 goals is to end hunger, achieve food security, and improve nutrition in a world where poor nutrition is still responsible for 45% of deaths among children under the age of 5 (UN, 2016).

With regard to improving nutrition, the target is to end malnutrition by 2030 (UN, 2016). Malnutrition is the state in which the body does not receive a balanced level of energy and nutrients required for normal growth leading to three conditions: undernutrition, micronutrient-related malnutrition, and obesity (World Health Organization [WHO], 2017). Undernutrition is the condition where the body does not receive a sufficient amount of nutrients. Child undernutrition presents in the form of stunting (short length/height for age), wasting (low weight for height), underweight (low weight for their age) and micronutrient deficiency (United Nations Children's Fund [UNICEF], 2013). In emergencies, the level of wasting is used to assess the health of an entire population where moderate wasting indicates moderate acute malnutrition (MAM) and severe wasting indicates severe acute malnutrition (SAM) while the presence of both MAM and SAM indicates global acute malnutrition (GAM; WHO, 2000). According to the International Food Policy Research Institute (2016), 23.8% of all children in the world under the age of five are stunted, 6.1% are underweight, 7.5% are wasted, and 2.4% are severely wasted. High levels of undernutrition and its impact on child survival and development, coupled with its long-term effect on adulthood require attention if the global goal of ending all forms of malnutrition is to be realized.

The situation of undernutrition in Somalia is one that shows a high burden of childhood nutrition. In Somalia, undernutrition is chronic, with one in eight children under the age of 5 being severely malnourished (World Food Program [WFP], 2018) while the population level of acute undernutrition (wasting) is often above the critical level of 15% (UNICEF, 2016). In 2012, the World Health Assembly developed an implementation plan regarding maternal, infant, and young child nutrition, setting a target to reduce stunting by 40% and reduce and maintain childhood wasting under 5%, which is also an SDG target (WHO, 2014; UN, 2016). Achieving these global targets will take a greater effort in terms of reducing undernutrition in countries like Somalia that contribute significantly to the global problem.

The purpose of this study is to examine trends in the prevalence of undernutrition and predictors of undernutrition in Somalia to generate evidence that policymakers could use to develop programs and policies to address childhood undernutrition. In this chapter, I describe the background of the study, problem statement, purpose of the study, and research questions. I also present the theoretical and conceptual framework of the study, provide definitions of key terms used, and describe the delimitations, limitations, and significance of the study.

Background

Child Survival and Development in Somalia

Somalia is emerging from being a failed state to becoming a stable nation. According to Randa, Whimp, Abdullahi, and Zacchia (2015), the country is undertaking policy and legal reforms to facilitate economic growth with good prospects of positive economic reaction, although challenges involving insecurity, lack of access to finance, and unequal distribution of resources threaten this positive progress. Access to education is slowly improving, with more children enrolled in schools, although % of primary school-aged children remain out of school (UNICEF, 2016b). The health sector is also growing, with improvements in governance and access to the Essential Package of Health Services (EPHS) enabled by programs such as the Joint Health and Nutrition Program. Improvements in the economy, education, and public health suggest positive prospects for improving human development in Somalia.

Despite the progress that the country is making, Somalia remains one of the toughest places for children to live and grow. Global under-five mortality data shows that in 2017, Somalia's under-five mortality rate (U5MR) of 127 per 1,000 live births is still among the worst in the world showing that children born in Somalia have reduced chances of making it to their fifth birthday (The World Bank, n.d.). Further, the United Nations Development Program UNDP (2016) estimated that 81.8% of the population in Somalia live in multidimensional poverty. People who live in multidimensional poverty experience deprivation resulting from several factors such as poor health, poor education, poor standard of living, and poor quality of work, low income, disempowerment, and threats of violence (Oxford Poverty and Human Development Initiative [OPHI], n.d.). Continued political instability and conflict in most of the central and southern parts of the country continues to weaken government institutions and systems and therefore the ability to provide basic health, nutrition, and education services that children need to grow and thrive.

Burden of Undernutrition in Somalia

In Somalia, one in seven children dies before their fifth birthday, with undernutrition understood to be the underlying cause in over a third of deaths (UNICEF, 2016). Kinyoki, Berkley, Moloney, Kandala, and Noor (2015) reported that between 2007 and 2010, the prevalence of wasting and stunting in Somalia were 21% and 31%, respectively. Kinyoki et al. (2016) added that over the same period, 9% of children were wasted and stunted, 29% were stunted and underweight, and 20% were wasted and underweight. In 2011, the prevalence of GAM in Southern Somalia rose above 30%, prompting a declaration of famine (Hillbruner & Moloney, 2012). While the famine situation in Somalia was undeclared in February 2012, conditions of high acute malnutrition rates and mortality have continued to prevail in South Central Somalia (SCS). In February 2017, Famine Early Warning System Network (FEWS NET) and the Food Security and Analysis Unit (FSAU) warned of another risk of famine in Somalia, indicating a rising level of acute malnutrition with GAM and SAM above the emergency thresholds in some parts of the country. Extensive humanitarian assistance kept the famine situation at bay, but there is always a threat of deteriorating conditions with elevated levels of acute malnutrition.

Undernutrition in Somalia continues to be high because of deep underlying factors such as conflict, lack of essential services and reduced coping mechanisms in the face of different climatic shocks like drought (UNICEF, 2016). These underlying factors are the drivers of household level factors such as low dietary diversity, poor access to safe water and improved sanitation facilities, inadequate infant care and feeding practices, disease, and poor access to health services that are often the immediate causes. While undernutrition that is visible because of wasting is often a more pressing challenge for Somalia, the prevalence of stunting also calls for integrated programs that address both forms of undernutrition.

The burden of undernutrition in Somalia is not the same across the country, which is indicative of disparities in terms of prevalence of this public health challenge. The south and central parts of Somalia have higher prevalence rates of undernutrition compared to the rest of the country (Kinyoki et al., 2015). Further, there are more stunted children in the southern and central regions compared to the rest of the country and more stunted children among IDPs and the rural populations (UNICEF, 2016). Disparities in terms of the burden of undernutrition in Somalia could point to social determinants of health as potential drivers of undernutrition in Somalia.

Humanitarian Context and Undernutrition in Somalia

Somalia experiences a complex combination of armed conflict, natural hazards like drought, economic crises, and poverty that persistently place the country into a state of humanitarian emergency (UNDP, 2017). A combination of these extreme humanitarian factors precipitated the 1991-1992 and 2011-2012 famine that resulted in high mortality rates. The 1991-1992 famine led to deaths as high as 74% of children under the age of five in some areas of SCS (Moore et al., 1993). According to Moore et al. (1993), observed deaths were due to preventable causes, mainly measles, and diarrhea, which were prevalent due to the absence of community health programs in light of heightened insecurity.

Similarly, the 2011-2012 famine resulted in the death of an estimated 258,000 people in SCS, 52% (133,000) of whom were children under the age of five. According to Checchi & Robinson (2013) these deaths were a result of the "combined impact of drought, reduced humanitarian assistance, high food prices, and civil strife and their downstream effects all in a context of persisting and worsening insecurity" (p. 10). The interwoven humanitarian crises in Somalia exacerbate the situation of undernutrition and overall child survival and development.

National Policies and Actions to Address Undernutrition

In 2010, Somalia developed its first-ever national nutrition strategy providing a framework for responding to persistently high rates of undernutrition in the country. Cognizant of limited resources available in Somalia, stakeholders focused the strategy on targeting pregnant mothers and children up to the age of 2 years as the critical window of intervention. The Somalia nutrition strategy aims at enhancing survival and development of the Somali people by increasing access and use of services for the management of undernutrition and the increasing availability of nutrition information (WHO, UNICEF, WFP, FAO, & FSNAU, 2010). The nutrition strategy focuses on increasing uptake of appropriate infant and young child feeding (IYCF) practices, improving coverage of micronutrient and deworming interventions, mainstreaming nutrition into other relevant sectors and improving in-country capacity to provide nutrition services (WHO, UNICEF, WFP, FAO, & FSNAU, 2010). While this three-year (2011 -2013) strategy does not commit to achieving long term changes in nutrition and mortality indicators, its effectiveness remains unclear without a policy evaluation. The country has not developed another strategy post-2013; however, other current national policy frameworks and initiatives such as the South Central Somalia IYCF strategy, National Development Plan (NDP), and the Scaling Up Nutrition (SUN) movement express similar ambitions and goals of improving the status of nutrition among children.

South Central Somalia IYCF Strategy and Action Plan

SCS had a 5-year (2013 -2017) IYCF strategy and action plan that sought to increase efforts involving preventing undernutrition as opposed to mainly focusing on managing acute malnutrition (Somalia Nutrition Cluster, 2012). This strategy is yet to be updated. The WHO and UNICEF recommend early initiation of breastfeeding and exclusive breastfeeding for the first 6 months of life and the introduction of complementary solid foods at 6 months together with continued breastfeeding for up to 2 years of age or beyond as essential IYCF feeding practices for preventing undernutrition (WHO, 2016). Early initiation of breastfeeding reduces the risk of underweight while appropriate complementary feeding has an effect of reducing the risk of stunting. While evidence on the positive impact of IYCF practices has grown, the uptake of these practices in Somalia remains dissatisfactory, with only 1 in 10 children fed according to WHO/UNICEF guidelines for combining breast milk and complementary solid foods at the age of one (UNICEF, 2016). Poor uptake of recommended IYCF practices is related to factors such as poor knowledge of the importance of optimal IYCF practices, social and cultural beliefs that hinder adoption of the practices, and food insecurity that limits caregivers' ability to provide dietary diverse and adequate food for young children. The IYCF strategy and plan for SCS sets out to address these barriers by providing a policy framework, employing strategies that address social and cultural barriers to adopting IYCF practices and ensuring collaboration of stakeholders involved in promoting IYCF (Somalia Nutrition Cluster, 2012). The IYCF strategy also focuses on increasing skills and knowledge of service providers in IYCF and ensuring availability of quality IYCF services. An evaluation of this strategy at the end of its implementation period would indicate the extent to which it has been useful in contributing to the reduction of undernutrition and promoting survival and development of young children in Somalia.

Somalia NDP

The government of Somalia outlined its plans for improving nutrition in a NDP for 2017-2019. Developed through a consultation process, the NDP acknowledged the need for holistic action through a coordinated approach to address the multiple causes of undernutrition (Federal Government of Somalia, 2017). The NDP focuses on improving access to services, strengthening access to nutrition information, and strengthening the capacity of national bodies to deliver sustainable nutrition services (Federal Government of Somalia, 2017). Compared to the SDG and global targets of reducing stunting by 40% and maintaining wasting to under 5% by 2025, the Federal Government of Somalia targeted to reduce stunting by 42% and reduce wasting to under 10%, which are ambitious targets for the 3 years of the NDP. Achieving these goals will require well-focused strategies and resources. The Somalia NDP also set targets to reduce underweight in children under the age of 5 by 33% (from 13.4 to 9%) by 2019 (Federal Government of Somalia, 2017). The nutrition goals outlined in the Somalia NDP are well aligned with SDG number two and global nutrition goals, although set targets could be high considering the current nutrition situation and scale of nutrition programs in the country.

SUN Movement

The SUN movement is a network of civil society, the UN, donors, businesses, and researchers working with national governments to improve nutrition. . The role of the SUN movement in Somalia is confirmed was corroborated by a nutrition causal analysis in Somalia, that established that the causes of undernutrition were multidimensional and therefore required multistakeholder and multidisciplinary solutions (Strengthening Nutrition Security in South Central Somalia [SNS] Consortium, 2015). Somalia joined the SUN movement in 2014, and by 2016, it established an inter-ministerial committee, UN network, and academic network as platforms for engagement in the fight to reduce malnutrition. While policies and legal frameworks for addressing undernutrition have been strengthened, and stakeholders are working on a common framework for interventions, resources that are required to turn the policies and programs into reality remain a challenge with most funds dedicated to short-term life-saving interventions. In 2018, SUN stakeholders developed a social mobilization, advocacy and communications strategy for 2019-2021 that is aimed at improving nutrition through ownership and support of agreed agenda such as the Common Results Framework (Scaling Up Nutrition, 2014). As a body that brings together different stakeholders for collective action, the movement has the space to contribute to reducing undernutrition in Somalia despite the challenges that the government of Somalia faces.

Problem Statement

The global movement to improve nutrition and end all forms of malnutrition requires data for policy development, program planning, and early warning regarding shocks that exasperate the nutrition status of affected populations. Such data is generated from nutrition surveillance systems whose objectives should be fivefold. One objective is to describe the nutritional status of the population, especially those at risk; the second is to enable an analysis of causes and factors associated with malnutrition. The third objective is to generate information that supports governments decision-making; while the fourth is to facilitate prediction of the nutrition situation and related policy formulations and the fifth objective is monitoring and evaluation of nutritional programs. While the objectives of surveillance systems are defined, the ability of the surveillance systems to meet the defined objectives and expectations may not always be evident.

In low-income countries, one of the main components of nutrition surveillance systems is large-scale nationally representative cross-sectional surveys, typically the Demographic Health Survey (DHS) and Multi-Cluster Indicator surveys (MCIS). However, the time lag between these surveys makes them unsuitable for comprehensive national policy and planning purposes in addition to being limited in tracking the prevalence of acute malnutrition that calls for rapid response (Tuffrey & Hall, 2016). As such, in countries like Somalia, where there is a need for more regular information for nutrition planning, repeated subnational cross-sectional surveys make up a large part of the nutrition surveillance system. Since 2000, FSNAU has been generating nutrition surveillance data as part of its food security and nutrition analysis system. The unit oversees the undertaking of two seasonal nutrition assessments: post-Gu (April-June) and post-Deyr (October-December). Gu is the main rainy season that lasts from April to June while Deyr is the second rainy season that lasts from October to December. The FSNAU uses data from these nutrition surveys to generate a nutrition analysis which all nutrition program planners and implementers in Somalia use for planning their response.

The FSNAU manages Somalia's nutrition surveillance system. Despite producing a range of reports that enable monitoring of the nutrition situation in Somalia, this system does not include rigorous trends and underlying causes that would give nutrition stakeholders an understanding of how this problem is evolving to allow prediction of the future nutrition situation and requisite policy formulations. Nutrition program planners, program implementers, and donors in Somalia therefore rely on seasonal information which is most suitable for short-term planning and implementation of programs. There is an absence of empirical evidence regarding trends of prevalence and predictors of undernutrition among children under the age of 5 in Somalia that could be useful for program planners, policymakers, and donors supporting long-term planning and development of policies to address undernutrition.

While global trends of undernutrition have been widely studied, national-level trends for countries like Somalia that would provide useful information for country-level planning and action to solve malnutrition problems have not been examined. Kinyoki, Berkley, Moloney, Kandala, and Noor (2015) examined the prevalence and predictors of malnutrition in Somalia between 2007 and 2010 and established that the national prevalence of wasting, stunting and low mid-upper arm circumference were 21%, 31%, and 36% respectively. Kinyoki et al. also established that fever, diarrhea, sex, age, household size, access to food, and enhanced vegetation index were significant predictors of malnutrition. However, beyond this study, there is no evidence of further research on trends and predictors of malnutrition despite changing weather, political, social, and economic dynamics that could affect the nutrition situation in Somalia. Additionally, Kinyoki et al. (2015) did not consider child feeding, water, sanitation, and access to health service as other important risk factors for malnutrition in children leaving a gap in knowledge of their relationship with childhood malnutrition in the context of Somalia. An expanded analysis of the trends in prevalence and predictors of undernutrition at the individual, household, and society level in SCS could provide insights for appropriate nutrition programs and policy development.

Purpose of the Study

Poor access to food, child feeding practices, water and sanitation, diseases, and lack of access to health are significant predictors of childhood undernutrition at the household level (Fekadu, Mesfin, Haile, & Stoecker, 2015; Lassi, Das, Zahid, Imdad, & Bhutta, 2013; Psaki et al., 2012; Kinyoki, Berkley, Moloney, Kandala, &Noor, 2015). In this study, I examined the effect of these factors on undernutrition at the child and household level in the context of SCS. I examined trends in terms of prevalence and predictors of undernutrition. I also examined the influence of geographical location, livelihood system, and armed conflict as risk factors for child undernutrition at the society level. In discussing ways to address structural and social issues that drive inequality in child health outcomes, Bell, Donkin, and Marmot (2013) research to show the effect of social determinants of health on child health outcomes. This study contributes to the understanding of the role that geographical location, livelihood system, and armed conflict as social factors have on health and nutrition outcomes for children in SCS. Findings from this study were aimed at generating knowledge regarding the prevalence and predictors of undernutrition among children under the age of 5 in Somalia that could be immediately useful for planners and implementers of programs focused on reducing undernutrition in this country. Additionally, findings regarding trends of prevalence and predictors of undernutrition in Somalia would inform the adaptation of national SDG targets for reducing malnutrition in Somalia and actions that nutrition program implementers, policymakers, and development partners in Somalia need to take to achieve set goals.

Research Questions and Hypotheses

The research on trends in prevalence and predictors of undernutrition among children in SCS sought to answer the following questions:

RQ1: What are trends in terms of prevalence of underweight, stunting, and wasting in SCS from 2007 to 2012?

RQ2: Is disease (diarrhea, malaria, Acute Respiratory Infections (ARI) and measles) associated with underweight, stunting, or wasting in SCS?

H_0: Underweight, stunting and wasting are not associated with disease namely Diarrhea ($H_0$1), Malaria ($H_0$2), ARI ($H_0$3), and Measles infection ($H_0$4).

H_a: Underweight, stunting and wasting are associated with disease Diarrhea ($H_0$1), Malaria ($H_0$2), ARI ($H_0$3), and Measles infection ($H_0$4).

RQ3: Are dietary diversity, child feeding practices (exclusive breastfeeding and minimum meal frequency), access to safe water, and access to health care associated with underweight, stunting, or wasting in SCS?

H_0: Underweight, stunting and wasting are not associated with dietary diversity ($H_0$5), child feeding [exclusive breastfeeding ($H_0$6) and feeding frequency ($H_0$7)], access to safe water ($H_0$8) and access to health care disease ($H_0$9).

H_a: Underweight, stunting and wasting are associated with dietary diversity (H_a5), child feeding practices [exclusive breastfeeding (H_a6) and feeding frequency (H_a7)], access to safe water (H_a8) and access to health care disease (H_a9).

RQ4: Is the area of residence, livelihood system, and armed conflict associated with underweight, stunting, or wasting in SCS?

H_0: Underweight, stunting and wasting vary by area of residence ($H_0$10), Livelihood system ($H_0$11) and armed conflict ($H_0$12)

H_a: Underweight, stunting and wasting do not vary by area of residence (H_a10), Livelihood system (H_a11) and armed conflict (H_a12)

RQ5: Are dietary diversity, disease, child feeding practices, access to safe water, access to health care, displacement, area of residence, livelihood system, and armed conflict significant predictors of underweight, stunting, and wasting in SCS between 2007 and 2012, when all levels of exposure are considered simultaneously?

H_0: Dietary diversity, disease, child feeding practices, access to safe water and access to health care displacement, the area of residence, livelihood system and armed conflict do not have a relationship with underweight, stunting, and wasting when all levels of exposure are considered simultaneously.

H_a: Dietary diversity, disease, child feeding practices, access to safe water and access to health care displacement, the area of residence, livelihood system and armed conflict have a relationship with underweight, stunting, and wasting when all levels of exposure are considered simultaneously.

RQ6: How do predictors of underweight, stunting, and wasting in SCS change between 2007 and 2012?

Theoretical and Conceptual Framework

Bronfenbrenner (1994) said that humans develop in a process through which the developing person interacts with the immediate or proximal environment, and the remote or distal environment. This concept forms the ecological systems theory and model.Bronfenbrenner (1994) added that the ecological system in which growth occurs must be considered to understand human development. According to the ecological systems model, a child's individual biological and psychological characteristics are influenced by the immediate physical and social environment (microsystem) as well as interactions within the immediate the environment (mesosystems). The microsystem environment is also affected by other broader social, political, and economic conditions (exosystem) that are also influenced by societal beliefs and attitudes (macrosystems; Bronfenbrenner, 1994). The ecological systems model that takes a system thinking approach has developed into socioecological models that apply the same concepts. For instance, the UNICEF conceptual framework of determinants of undernutrition is a framework for examining health outcomes for children through the lenses of the ecological model.

The UNICEF conceptual framework of determinants of undernutrition (see Figure1) identifies causes of undernutrition among children as immediate, underlying, and basic causes (UNICEF, 1990). According to this framework, exposure to disease and inadequate dietary intake in children are the immediate causes of undernutrition. However, within each child's household, there are causes such as insufficient access to food, poor maternal and child feeding practices, and poor health conditions including lack of safe water and sanitation that influence immediate causes of undernutrition. These household level causes are proximal factors that affect a child's nutritional status. Beyond the causes of undernutrition at the household level, there are wider social causes such as social, economic, and environmental conditions that influence proximal factors by determining the quality and quantity of resources available in the household. Factors at the society level are distal, and they are the root causes of undernutrition in children.

This study will be using the UNICEF] conceptual framework of determinants of undernutrition, applying the framework to the Somalia context in examining both proximal and distal factors related to undernutrition in children. This conceptual framework has been used in both research and development of nutrition programs, although most investigations and program implementation have focused on understanding and addressing proximal factors.

Nature of the Study

This study adopted a quantitative study design using secondary data collected from cross-sectional nutrition surveys conducted by the FSNAU in Somalia. The study is a nonexperimental design because it is not seeking to establish causation; instead, it aims to examine the relationship between variables over a period of time. The dependent variable in this study was undernutrition measured as wasting, stunting, and underweight, while dietary diversity, disease, child feeding practices, access to safe water, access to health care, displacement, area of residence, livelihood system, and incidence of armed conflict were independent variables.

Definition of Terms

Malnutrition: Malnutrition is a state in which the body does not get the required level of nutrients to function properly; this would be a deficiency or an excess or imbalance of nutrients. Malnutrition thus covers two conditions: undernutrition, when the body does not receive a sufficient amount of nutrients, and overweight or obesity, where the body has an excess fat accumulation (WHO, 2016). In this study, the term malnutrition is used to refer to the condition of undernutrition, and like in most literature, the two terms are used interchangeably to refer to the body receiving insufficient amounts of nutrients.

Stunting: Stunting is a form of undernutrition where a child's normal growth and development is retarded because of a persistently poor diet, repeated infection, and poor psychosocial stimulation (WHO, 2017a). A child who is stunted is too short for their age.

Undernutrition: Child undernutrition is defined as an outcome of insufficient food intake and repeated infection. It presents in the form of stunting (short length/height for age), wasting (low weight for height), underweight (low weight for their age) and micronutrient deficiency (UNICEF, 2013).

Underweight: Underweight is a form of undernutrition where a child is too thin for their age as a result of wasting or stunting or both (WHO, 2010).

Wasting: Wasting is an indication of acute malnutrition, often as a result of inadequate food intake or a high incidence of infectious diseases, especially diarrhea (WHO, 2010). Wasting weakens the immune system, increasing the susceptibly and severity of infections, and therefore the likelihood of death (WHO, 2010). A child who is wasted loses bodyweight, becoming too thin for their height/length.

Assumptions

Several assumptions inform this study. Data collected regarding household characteristics household diet diversity, access to water, and access to sanitation facilities in individual households was assumed to be the same for all children living in that household. Any differences in terms of effects of household characteristics on individual children's nutrition status could bias the study results, but this was controlled in the data analysis using a GEE approach that is suitable for correlated data. I also assumed that all data collection procedures and techniques, especially in terms of taking anthropometric measures of body weight and height, followed the Somalia nutrition survey guidelines. Any departures from the survey guidelines could introduce errors in the accuracy of the data.

Scope and Delimitations

In this study, I used secondary data from nutrition surveys implemented by FSNAU between 2007 and 2012. Secondary data is delimited to children aged 6-59 months, and the mother of the child or responsible caregiver where the child's mother was absent. This is an observational study that examined relationships between predictors of undernutrition and undernutrition prevalence but not causal relationships that would have to be established through experimental studies.

Limitations

The main limitation of this study was the use of secondary data for which there was no complete control over the study variables, given that the primary data determined possible data variables. I also had a limitation in examining immediate predictors of undernutrition, where a key variable on individual child dietary intake was not measurable because the primary data did not consistently have data on individual child dietary intake. The other limitation was inconsistent sample sizes for the two biannual seasonal surveys which could have been a result of data collection activities failing to reach all desired communities due to insecurity created by armed conflict in the region

Significance

Different stakeholders that partner with the government of Somalia to implement programs aimed at reducing undernutrition among children use biannual nutrition surveillance information generated from seasonal nutrition surveys. In the absence of trend analysis, this seasonal monitoring information is not sufficient for long-term planning and decision-making regarding preventing mortality and morbidity due to undernutrition. This research will generate information on trends and predictors of undernutrition in Somalia, which will support long-term planning and development of nutrition programs and policies to address the chronic nature of undernutrition among children. The study will give nutrition program planners and decision-makers in Somalia a contextual understanding of the effects of seasonal weather changes, urbanization, displacement, and geography on the prevalence and predictors of undernutrition in children in Somalia. This knowledge will enable the design and implementation of appropriate nutrition response interventions to address undernutrition in Somalia. The findings of this research will inform policy and practice geared towards the realization of two SDGs concerning improving nutrition in Somalia.

Summary

Elimination of childhood undernutrition in its different forms is a global goal behind which national governments and international bodies in both the public and private sector have made several commitments. However, to address the undernutrition problem, all stakeholders, especially those at the national government level, need well-analyzed data and synthesized information to develop nutrition programs, early warning systems, and policies. Building on current information systems, this study seeks to present such data and information to the government of Somalia.

This chapter provided a background context of the undernutrition situation in Somalia and actions that are being taken to address the problem. The chapter also presented the gap in knowledge that this study seeks to address and specific research questions for the study. In this chapter, I also described the nature and scope of the study, limitations, and significance of the study. In Chapter 2, I present the theory and literature that anchors this study.

Chapter 2: Literature Review

Introduction

The purpose of this study is to generate empirical evidence regarding trends in prevalence and predictors of undernutrition among children under the age of five in SCS that could be used to develop long-term nutrition programs and policies. In the study, I will examine the application of existing evidence regarding undernutrition causal pathways in the context of Somalia and predictors of undernutrition that are most critical to address in the fight against childhood undernutrition. The UNICEF conceptual framework of determinants of undernutrition will be used to guide the overall research framework for this study.

In this chapter, I discuss current literature regarding undernutrition in children. The first section presents the theoretical and conceptual framework, discussing the application of the ecological model and the UNICEF conceptual framework of determinants of undernutrition in understanding immediate and underlying causes of undernutrition in children. The second section discusses the different forms of undernutrition in children and how they affect normal growth. The third section examines evidence on the short and long-term effects of childhood undernutrition. The fourth, fifth, and sixth sections focus on existing evidence on the immediate, proximal, and distal causes of undernutrition in children. The seventh and last section of this chapter presents literature on interventions and programs that research and practice have revealed to address undernutrition in children.

Strategy for Literature Review

For this literature review, I searched MEDLINE, and PubMed databases and used Google Scholar search engine to find articles on undernutrition in children using the terms undernutrition, malnutrition children, predictors, outcomes, and trends. The keywords were used in different combination to get the most relevant articles. I narrowed down the articles from the first search to articles that were not more than 5 years old and focused on children under the age of five. In addition to the search using key terms, I used reference lists to further identify and search for other recent and related articles. While the search focused on articles not older than 5 years, I included a few older articles because of the importance that they have in shaping evidence and practice in childhood undernutrition. I constructed a literature matrix to summarize key findings from the different articles, then analyzed and grouped the results into themes and sections for this chapter.

Theoretical and Conceptual Framework

Bronfenbrenner (1994) said that human development is a process of interaction between the developing person, the immediate or proximal environment, and the remote or distal environment. Bronfenbrenner’s ecological paradigm has two main arguments. The first argument is that development, especially in the early years of life, is subject to an interaction between the human being and what is found in their immediate or proximate environment (Bronfenbrenner, 1994). The proximate environment includes places such as family and school. The second argument is that the effect of the proximate environment on development depends on the development outcome in question and the interaction of the developing individual with their immediate and remote environment, which makes the first and the second arguments codependent (Bronfenbrenner, 1994). The codependence of the two arguments illustrates the interaction between a developing individual and the environmental context in which they live. In light of the ecological model, nutritional outcomes depend on the interaction of individual child characteristics with processes in their family or school which in themselves are influenced by factors in the wider community and society where the family or school is embedded. Bronfenbrenner thus concluded that human development should be examined in the context of ecological systems. Ecological models, therefore, describe human development in relation to the environment in which humans live. The UNICEF conceptual framework of determinants of undernutrition applies the ecological theory in defining undernutrition and its causes.

The UNICEF conceptual framework of determinants of undernutrition (see Figure1) identifies the causes of undernutrition among children as immediate, underlying, and basic (UNICEF, 1990). According to this framework, exposure to disease and inadequate dietary intake in a child are the immediate causes of undernutrition. However, disease and inadequate dietary are influenced by factors within the child’s household such as insufficient access to food, poor maternal and child feeding practices, and poor health conditions including lack of safe water and sanitation. These household level or proximal factors that affect a child’s nutritional status are the underlying causes of undernutrition, according to the conceptual framework. Beyond the causes of undernutrition at the household level, there are wider social, economic, and environmental conditions that influence proximal factors by determining the quality and quantity of resources available in the household. Factors at the society level are distal, but they are the root causes of undernutrition in children. While the UNICEF conceptual framework of determinants of undernutrition , categorizes the causes of undernutrition as immediate, underlying, and basic causes, public health scholarly language in uses different terminology that considers the causes of undernutrition to be immediate child level factors, proximal factors, and distal factors which are the social determinants of health.

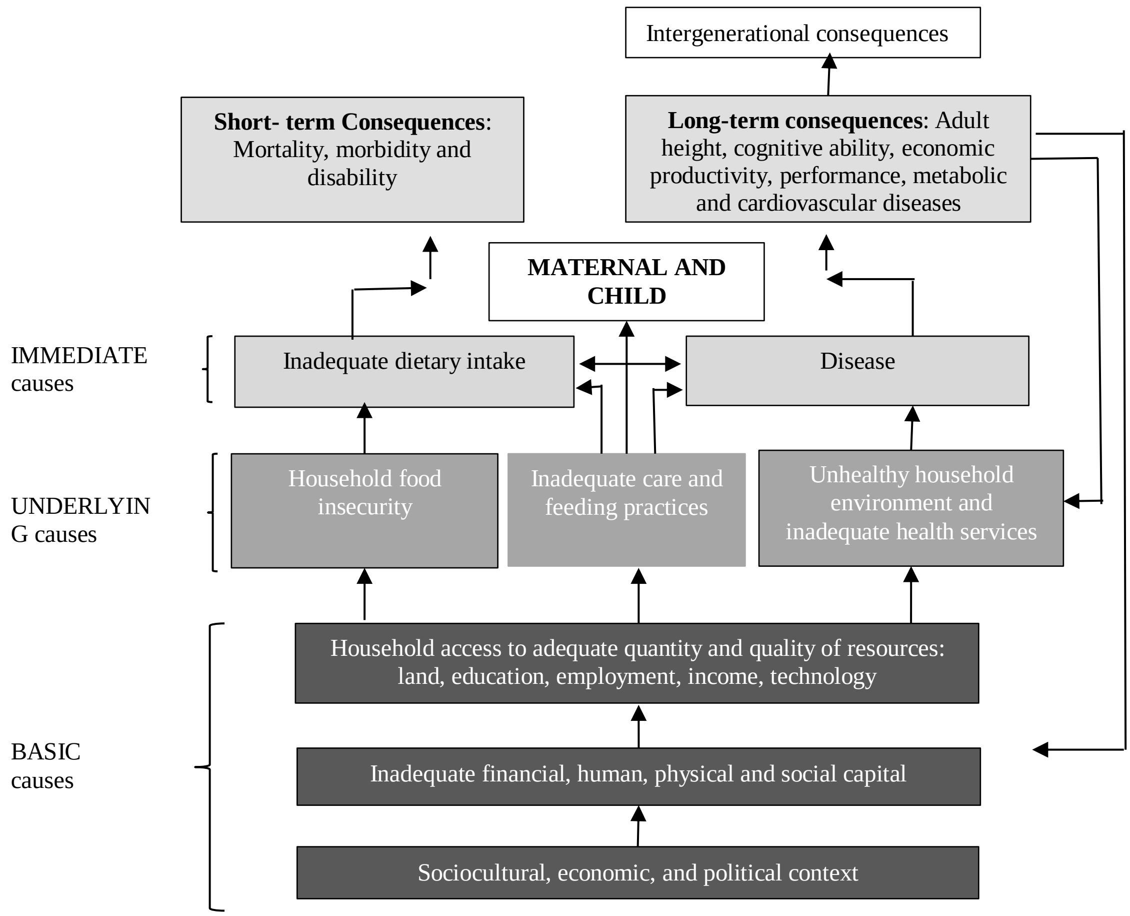

Figure 1. UNICEF conceptual framework of determinants of undernutrition

Adapted from UNICEF's approach to scaling up nutrition for mothers and their children by UNICEF (2015), p.9

This study will apply the UNICEF conceptual framework of determinants of undernutrition to the Somalia context examining child, proximal, and distal factors related to undernutrition in children under the age of five. Several studies have used the UNICEF conceptual framework to study causes of childhood undernutrition, although most investigations have focused on understanding and addressing proximal causes.

Forms of Undernutrition in Children

Undernutrition in children increases vulnerability to morbidity and mortality. UNICEF (2017) estimated that almost 3 million children die annually because of causes attributed to undernutrition. According to the WHO (2019b), there are four forms of undernutrition in children: stunting, wasting, underweight, and deficiencies in vitamins and minerals.

Stunting

Stunting is a result of growth failure. As an anthropometric indicator, it is defined as "the percentage of children aged 0 to 59 months whose height for age (HAZ) is below minus two standard deviations (moderate and severe stunting) and minus three standard deviations (severe stunting) from the median of the WHO Child Growth Standards" (United Nations Children's Fund, 2013, p.7). Growth faltering starts during pregnancy and continues through the age of 24 months with limited possibilities of catching-up.

Richard et al. (2012) demonstrated the phenomenon of failed catch up growth in stunted children using a longitudinal dataset where they established that children that had a stunting measurement before 12 months were more likely to be stunted at 12 months [OR = 2.6 (95% CI: 2.1, 3.1)] with the chances of being stunted increasing with any additional stunted measurements [2 stunted measurements: OR = 3.9 (95% CI: 3.0, 4.8); 3 stunted measurements: OR= 5.5 (95% CI: 4.9, 6.1)]. Stunting measurements in this study were taken at 3, 6, and 9 months. In an earlier study on growth faltering using data from national anthropometric surveys in 54 countries, Victora, Onis, Hallal, Blössner, and Shrimpton, (2010) also demonstrated that HAZ starts close to normal for new-borns but then decreases significantly over 24 months with very slight increases after that. This evidence supports the argument that the first 1000 days of life (inception to 24 months) provide an opportunity to address growth faltering beyond which the opportunity is lost.

Stunting has lifelong negative effects such as poor cognitive development, reduced productivity, and increased risk of chronic diseases in adulthood (UNICEF, 2013). In 2012, the World Health Assembly resolved to reduce stunting by 40% by the year 2025 with a call to states to enact policies and implement actions that would accelerate the pace of reduction (WHO, 2014b). De Onis, Blössner, and Borghi, (2011) had estimated the prevalence of stunting to be 26.7% (95% CI 24.8%, 28.7%) in 2010 translating to about 171 million children.

While the rate of stunting is reducing globally, it is not reducing at a rate that will lead to achieving the set global target. According to Black et al., (2013), the global target would mean reducing the number of stunted children from 171 million in 2010 to about 100 million by 2025, but at the current rate of decline, it is projected that there will still be about 127 million stunted children by 2025. In 2018, the UNICEF, WHO and World Bank Group joint malnutrition monitoring estimated that 22.2% of children under the age of five were stunted with a reduction in the number of stunted children across the world except in Africa where the number increased (UNICEF/WHO/World Bank Group, 2018). West Africa largely contributes the increase in stunting in Africa although, with 24 million children under five stunted, East Africa still has the largest share of stunted children on the continent (UNICEF/ WHO/World Bank Group, 2017). Overall, there is still a need for governments and other stakeholders to invest more in nutrition programs and policies if the global targets to reduce stunting are to be achieved.

Wasting

As an anthropometric indicator, wasting is defined as the "percentage of children aged 0 to 59 months whose weight for height (WHZ) is below minus two standard deviations (moderate and severe wasting) and minus three standard deviations (severe wasting) from the median of the WHO Child Growth Standards" (UNICEF, 2013, p.7). In children aged 6-59 months, severe wasting and/or mid-upper arm circumference (MUAC) less than 115 mm and/or bilateral pitting oedema is referred to as Severe Acute Malnutrition (SAM) while moderate wasting and/or mid-upper arm circumference (MUAC) of more than 115 mm but less than 125mm is referred to as Moderate Acute Malnutrition (WHO/UNICEF/WFP, 2014).

Children that have Moderate Acute Malnutrition (MAM) will progress to Severe Acute Malnutrition (SAM) if they do not receive appropriate nutrition support, which, increases their risk of death. WHO estimates a case fatality rate of 30% to 50% for SAM but advises that this rate can be reduced with proper treatment by around 55% in hospital settings (WHO,2017c). Severe acute malnutrition in children above six months that do not have medical complications can also be treated in community settings by giving children ready-to-use therapeutic food (WHO,2017c). Among disaster-stricken populations, refugees, or internally displaced people, a combination of children with SAM and MAM is used to estimate the Global Acute Malnutrition (GAM) that determines the severity of the nutrition situation and therefore the risk of increased mortality. GAM thus includes children aged 6-59 months whose weight for age is below -2 z-scores from the median of the WHO child growth standards with or with bilateral pitting edema. According to WHO, the prevalence of GAM (% below -2SD) of ≥15% is critical and requires an emergency response to save lives (WHO, 2000).

Wasting increases the risk of death in affected children. According to Olofin et al., (2013), children with severe wasting (WHZ≤ -3) are 11.63 (9.84, 13.76) times more likely to die in childhood than children that are not wasted (WHZ ≥ -1). Olofin et al., (2013) concluded that wasting was the most influential risk factor for mortality compared to underweight and stunting. While wasting increases the risk of death, it is a response to a short term food shortage or infection such that if children get the right treatment, they recover and get back on the path of normal growth especially if wasting is experienced in the earlier months of life. A study by Richard et al. (2012) revealed that wasting in the earlier months of life (0-11 months) did not have an effect on linear growth at 18-24 months however wasting in later months (12-17 months) had an impact suggesting that younger children have an opportunity to catch up growth unlike older children. Richard et al. (2012) further examined the relationship between wasting and stunting and established that the correlation between HAZ and WHZ increased with age and that children that experienced greater variability in WHZ had lower HAZ suggesting that wasting may play a role in the process of stunting.

The World Health Assembly in 2012 set a target to reduce and maintain wasting below 5% by 2025 however, in 2016 about 7.7% of children under the age of five were wasted indicating a 0.1% percent point reduction from 7.8% when the global target was set in 2012 (WHO/UNICEF/WFP, 2014; UNICEF/WHO/World Bank Group, 2017). Wasting among children in Somalia is a significant public health concern with prevalence often at critical levels that call for emergency response. High prevalence of wasting (GAM) in Somalia is due to food shortage and childhood diseases that are precipitated by drought, conflict, and lack of health services. Reducing the incidence of wasting to achieve global targets will require more significant action in countries with a high incidence such as Somalia, Nigeria, and India.

Underweight

According to UNICEF (2013, p.7) underweight as an anthropometric indicator is defined as “the percentage of children aged 0 to 59 months whose weight for age is below minus two standard deviations (moderate and severe underweight) and minus three standard deviations (severe underweight) from the median of the WHO Child Growth Standards”. Underweight children are at higher risk of death than children that are not underweight. According to Olofin et al., (2013), mildly underweight children are 1.52 times more likely to die in childhood (HRs of 1.52 [1.28, 1.81]) than normal children with the risk increasing in moderately (HR of 2.63 [2.20, 3.14]), and severely underweight children (HR of 9.40 [8.02, 11.03]). While previously monitored among the global indicators of child nutrition, underweight is not among the 2025 global targets for nutrition because of the challenge it presents as a composite indicator that combines wasting and stunting.

Effects of Undernutrition

Undernutrition has an immediate impact on children's survival and development that continue into adulthood to affect health and human productivity and further to influence the next generation perpetuating a vicious cycle of poverty and disease. Black et al. (2013) present a life course view on the effect of childhood undernutrition, highlighting its impact on childhood, adolescence, and adulthood. The effects of undernutrition will range from morbidity and mortality in infancy through cognitive, socioemotional development, school performance and learning capacity in childhood and adolescence to stature, obesity, and noncommunicable diseases, and work productivity in adulthood.

Mortality and Childhood Undernutrition

Undernutrition in children increases the risk of mortality from diarrhea, pneumonia, measles, and other infectious diseases. In a pooled analysis of data from children aged one week to 59 months old collected in 10 prospective studies in Africa, Asia, and South America, Olofin et al., (2013) established that any level of underweight, stunting and wasting is associated with an increased risk of mortality. The study revealed that mild underweight (WAZ $-2 \leq Z < -1$) increased the risk of death by 1.52 times (CI = 1.28, 1.81) while severe underweight (WAZ < -3) increased the risk by 9.4 times (CI = 8.02, 11.03). The study also revealed that mild wasting (WHZ $-2 \leq Z < -1$) increased the risk of mortality by 1.62 times (1.41,1.87) while severe wasting (WHZ < -3) increased the risk by 11.63 (9.84, 13.76) times. Further, mild stunting (WHZ $-2 \leq Z < -1$) increased the risk of all-cause mortality by 1.46 (1.23,1.74) times while severe stunting (HAZ≤ -3)

increased the risk by 5.48 (4.62, 6.50) times. Tette et al. (2016) also established that malnutrition increased the chances of dying by more than 4 times (adjusted OR = 4.32 [95 % CI, 1.33–13.92], p = 0.014]) when malnourished children and well-nourished children under the age of five where compared in a facility based case-control study in Ghana.

While the individual growth defects increase the risk of mortality, a combination of the defects aggravates the situation. Mcdonald et al., (2013) established that two combined conditions such as wasting and underweight or stunting and underweight increased the risk of mortality compared to having one condition while a combination of all conditions had the most significant effect with the risk of death increased more than 12 times when compared with children that didn’t have any of the conditions. These studies demonstrate that undernourished children are at a higher risk of dying in childhood than children that are not undernourished with the risk of death increasing among children with multiple defects.

Overall, child deaths related to nutrition conditions are significant, with an estimated proportion of 45% of all global child deaths in 2011(Black et al., 2013). Achieving the Sustainable Development Goals will, therefore, depend on success in addressing childhood undernutrition given the large proportion of child deaths that are contributed by nutrition-related causes.

Cognitive, Mental Development, and Schooling

Undernutrition in childhood has a negative effect on cognitive development, mental development, and education outcomes for children. In their study, Black et al.

(2008) established that height-for-age and weight-for-age were strong predictors for schooling with about 0·50 years of schooling per Z score and 0·52 years per Z score, respectively. Positive school outcomes are supported by other findings such as those established in a multi-country study that examined a cohort of 8062 children in Ethiopia, India, Peru, and Vietnamese over an 8year period (Crookston et al., 2013). In this study, height for age was established at the age of 1 and subsequent data collection points when the children were four and eight years old. Through these waves of data collection, the researchers grouped the children into four categories that were used to assess the association between growth and schooling outcomes. The four groups of children were those that were persistently stunted (stunted at ages 1 and 8 y), those that recovered (stunted at age 1 y and not stunted at 8 y), those that faltered (not stunted at age 1 y and stunted at age 8 y), and those that were never stunted (not stunted at ages 1 or 8 y). Results of the study revealed that children who were persistently stunted were more likely to be overage for their grade compared to those who were never stunted [OR range; 1.71 -2.79], while those that faltered or recovered were likely to be overage for grade in half of the cases [OR range: 1.35–2.40 and 0.85–2.20, respectively] (Crookston et al., 2013). Further, the results revealed children that were persistently stunted or recovered had lower mathematics scores and receptive vocabulary scores compared to those that were never stunted while children who faltered and those who were persistently stunted had lower reading-comprehension scores than those that were never stunted.

Crookston et al. (2013) concluded that children that were never stunted had better outcomes than those that faltered, recovered or were persistently stunted while those that recovered had better results than those that were persistently stunted. Likewise, Waber et al. (2014) also established a similar effect of malnutrition on IQ and academic achievement by studying a Barbadian population that was followed for 40 years in the Barbados Nutrition Study. In this study, children that had been hospitalized because of malnutrition in their first year of life were compared with a matched healthy control group during childhood, adolescence, and adulthood. Results of the study revealed that individuals in the previously malnourished group were nine times more likely to have impaired IQ (odds ratio, OR=9.18, 95% confidence interval, CI= 3.50–24.13) and had more deficient academic skills than those in the control group who had never been malnourished (Reading, OR=3.44, 95% CI=1.88–6.30; Spelling, OR=6.10, 95% CI=3.34–11.16; Calculation, OR=6.23, 95% CI=3.15–12.32, all $P<0.001$ 1). Although Crookston et al. (2013) suggested that children that recovered had better outcomes than those that were persistently malnourished, Waber et al., observed that nutritional rehabilitation in the undernourished children did not improve outcomes pointing to the importance of prevention interventions as opposed to treatment programs. These studies provide evidence of the effect of childhood malnutrition on cognitive and mental development.

Adolescent and Adult Behavior

Adolescent and adult behavior is also influenced by malnutrition during infancy. Through the Barbados nutrition study, Galler et al. (2012a) found that adolescents that suffered from malnutrition in their first year of life reported a higher level of conduct problems than a comparison group that never suffered from malnutrition although they observed that the effect could have been mediated by IQ and standard of living. Further, Galler et al., (2012b) established that adults that had a previous history of malnutrition had an increased level of attention problems compared to a healthy control group. Adults in the previously malnourished group had higher CAARS (Connors Adult ADHD [attention-deficit hyperactivity disorder], Rating Scales) scores while there were some whose scores exceed the threshold for clinical diagnosis compared to none in the healthy comparison group (Galler et al., 2012b). Notably, CAARS remained significant after adjusting for the standard of living during childhood, indicating that childhood living conditions did not confound the effect of malnutrition on adulthood behavior. Important to observe in this longitudinal study is that while the previously malnourished population had been enrolled in a nutrition program for nutrition rehabilitation, the effects of malnutrition persisted into adolescence and adulthood. Galler et al., (2012b) thus conclude that investments in prevention of malnutrition would be more economical than treatment of malnutrition when viewed in the lenses of long-term social benefits. Results of this study highlight the importance of interventions to prevent malnutrition in childhood over interventions aimed at treating malnutrition.

Adulthood Stature

Victora et al. (2008) analyzed the consequences of maternal and child nutrition in adulthood. One of the consequences of childhood malnutrition is short stature in adulthood, which has effects on birth weight among women and productivity for both women and men. Victora et al., (2008) revealed that a Z score increase in weight-for-age at two years was associated with a 2·7 cm increase in adult height while a Z score increase in height-for-age at two years was associated with a 3·2 cm increase in adult height (Victora et al., 2008). These results imply that underweight and stunted children are likely to be shorter in adulthood, although there are arguments for a catch-up growth if environmental and nutritional conditions are improved in the younger years. The disadvantage of short stature in females that later become mothers continues to affect intrauterine growth by increasing the risk of term and preterm lower birth weight babies (Black et al., 2013). Several studies (Bove, Campoy, Uauy, Miranda, & Cerruti, 2014; Kirk et al., 2017; Mukhopadhyay, Louis, Mahajan, & Mahajan, 2014; Rahman, Howlader, Masud, & Rahman, 2016;) have shown that low birth weight increases the risk of being stunted, underweight or wasted; thus the vicious cycle of undernutrition is perpetuated.

Additionally, physical height may affect income and assets. In a multi-country study, Victora et al., (2008) established 1 Z score for height-for-age in men was associated with an 8% increase in income in Brazil ($p<0·0001$) and Guatemala ($p=0·07$), and an increase of 0·27 household assets in India ($p<0·0001$). For women, the same study established that height-for-age was associated with income in both Brazil and Guatemala (8% and 25%, respectively), and with the number of assets in India. These results point to the disadvantage that short stature might have on the ability to earn a living, especially in manual jobs that might require greater physical strength and height.

Obesity and NCD

Studies have suggested a relationship between stunting in the early years of life and obesity as well as non-communicable disease in adulthood. Sawaya and Roberts

(2003) endeavor to elucidate the physiological changes that happen in growth-retarded children that increase the risk of stunting while Sawaya, Martins, and Hoffman(2003) attempt to explain potential pathways between childhood undernutrition and obesity and chronic diseases. While both authors provided evidence to support their arguments, they recommend further research to better understand the relationship between child undernutrition, adulthood obesity, and chronic diseases. Martins et al. (2004) established that stunted boys gained more body fat and less lean mass compared to non-stunted boys after 3 years of follow up while stunted girls gained less lean mass and their fat mass increased between baseline and end of follow-up which was not the case with non-stunted girls. Lee, Nam, and Hoffman (2015) revealed changes in energy metabolism among stunted North Korean children living in South Korea that had malfunctioned growth and found increased chances of being overweight or obese in adulthood. However, Walker, Chang, and Powell (2007) found that children that were stunted at two years were less likely to be overweight at the age of 17 years but an increase in linear growth between 7-11 years was a significant predictor of increase in BMI. Walker, Chang, and Powell thus argued that early childhood stunting does not “predispose individuals to overweight in late adolescence” (p.351).

Tanner, Leonard, and Reyes-García, (2014) also established that stunting among Tsimane’ children and adolescents aged between two and ten years had an inverse relationship with BMI, skinfold body fat reserves, and arm muscularity after a six-year follow-up period. Tanner, Leonard, and Reyes-García suggested that the nature of their findings could be linked to the context in terms of access and consumption of high-fat diet and the level of physical activity. Other studies have suggested that metabolic changes in adulthood among individuals that were stunted in childhood are more associated with socioeconomic and environmental conditions rather than growth faltering experienced in childhood. Grillo, Gigante, Horta, and de Barros, (2016) demonstrate this argument in a study of a Brazillian cohort followed for 23 years from childhood into early adulthood. This study found that stunting was not associated with metabolic syndrome (measured by HDL-cholesterol, triglyceride, random blood glucose, waist circumference, blood pressure, body mass index) when previously significant relationships diminished upon controlling for confounding variables that included socioeconomic and environmental conditions. The contradictory evidence on the relationship between stunting and obesity suggests a need for further studies to understand the interplay between linear growth, age, diet, physical activity, and metabolic changes.

The short and long-term consequences of undernutrition demand urgent action to address its predictors at different levels. Research has demonstrated cost-effective interventions that work to reduce undernutrition including ten evidence-based nutrition interventions that could reduce child mortality by 15% if they were implemented at 90% coverage (Bhutta et al., 2013). Further, Hoddinott, Alderman, Behrman, Haddad, and Horton (2013) demonstrate benefit: cost ratios that exceed one for several nutrition-specific interventions arguing countries that wish to increase and sustain their wealth should consider investments in nutrition.

Immediate Causes of Undernutrition

Dietary Intake

The WHO and FAO recommend human nutrient requirements that countries should adopt in developing food-based dietary guidelines for their populations (WHO, 2018a). Nutrients that are recommended by WHO/FAO include protein, energy, carbohydrates, fats and lipids, a range of vitamins, and several minerals and trace elements (WHO, 2018a). WHO also recommends components of a healthy diet, although the exact composition that an individual eats may vary according to preferences, cultural context, and locally available foods (2018b). Children under six months should exclusively breastfeed as breast milk provides the best source of nutrients for that age while after six months, a child should eat “nutrient dense” complementary foods and continue breastfeeding up to 2 years (WHO, 2018b).

A diet which is adequate in quantity (calories) and quality (nutrients) is necessary for the development and protects children from the risk of undernutrition. In a study of 286 children aged 6-59 months that were randomly selected from households affected by HIV and AIDS in Kiambu Kenya, Chege, Ndungu, and Gitonga, (2016) established a significant relationship between the energy intake and nutritional status ($r = 0.78$ $p = 0.038$). According to Chege, Ndugu and Gitonga intake of vitamin A, iron, and zinc were lower than the recommended amounts perhaps linked to lack of nutrient-dense foods in the study area. Further, Chege, Ndugu, and Gitonga established that wasting in this study population was 9.9% compared to a national average of 7.0%. The study also showed that energy and micronutrient intake were correlated with both the number of meals and dietary diversity score (Chege, Ndugu & Gitonga, 2016).

Wong, Moy, and Nair (2014) also demonstrated the influence of inadequate dietary intake on children's nutritional status. In a case control study of children under the age of five that attended maternal and child health clinics in Terengganu - Malaysia, Wong, Moy and Nair established that childhood malnutrition [z-scores $< -2SD$ from the median of WHO reference] was significantly associated with dietary energy intake (AOR: 0.99, 95% CI: 0.98, 0.99), and vitamin A intake (AOR: 0.999, 95% CI: 0.997, 1.00) demonstrating their protective effect on undernutrition. Chege, Ndugu, and Gitonga illustrate a correlation between energy intake and nutritional status while Wong, Moy, and Nair show that dietary diversity and vitamin A are protective factors for undernutrition. Both studies reveal that children that consume more diverse diets and meals in a day are better protected from various forms of undernutrition.

Diseases and Infections

Diseases such as diarrhea, malaria, pneumonia, measles, and other infectious diseases increase the likelihood of undernutrition in children, especially in areas where there is limited access to health services. Overall, infections result into appetite loss, poor absorption of nutrients and diversion of nutrients to fighting disease and repairing the body tissue which predisposes children to undernutrition (Jones, Thitiri, Ngari, & Berkley, 2014). In her study on the predictors of undernutrition in Somalia, Kinyoki et al., (2015) found that fever and diarrhea were significantly associated with wasting and stunting. Ferdous et al., (2013) investigated the effect of diarrheal disease on malnutrition and established that stunting, underweight, and wasting among children aged 24 -59 months were significantly associated with disease severity. Several other studies have also shown that diarrheal diseases increase chances of malnutrition in children (Tette et al., 2016; Kinyoki et al., 2015; Fekadu et al., 2015). Ferdous et al. (2015) also established that malnourished children were more likely to have severe diarrheal diseases than well-nourished children pointing to the vicious cycle of malnutrition and infection. Infections increase the risk of malnutrition in children by affecting nutrient absorption and increasing nutrient loss; conversely, malnutrition decreases immunity, which increases susceptibility to infections (Jones, Thitiri, Ngari, & Berkley, 2014). This interaction is the vicious cycle of malnutrition and infection.

Environmental Enteric Dysfunction (EED) is a hygiene related infection that is associated with childhood undernutrition. Some scholars have even argued that compared to diarrhea, EED provides a better explanation for childhood undernutrition (Humphrey, 2009). While the case definition for EED, its causes and consequences are yet to be fully established, it is understood to be a common occurrence among children living in environments with poor hygiene and to result into impaired absorptive function, reduced permeability and inflammation of the small intestine with consequences for faltered linear growth and stunting (Keusch et al., 2014).

Several other scholars have explained the linkage between EED and undernutrition (Mbuya and Humphrey, 2016; Ngure et al., 2014; Keusch et al., 2014; Keusch GT et al., 2013) although field studies that generate evidence on this linkage are still limited. Weisz et al., (2012), for instance, demonstrated that EED among Malawian children aged 2 to 5 years was associated with reduced linear growth. Studying a population of rural Bangladeshi children, Lin et al., (2013) also established that children living in clean households had the higher height for age z scores (HAZ), lower prevalence of stunting and lower Lactulose:Mannitol (L:M) in urine when compared to children in contaminated households. Lin et al. also found that L:M ratio, which indicative of gut function, was strongly associated with HAZ. Some researchers are attempting to develop interventions that improve environmental conditions in which children grow so that they are protected from EED, such as the concept of baby WASH proposed by (Mbuya & Humphrey, 2016). However, these interventions are nascent and may not be entirely feasible in the contexts for which they have been proposed. While more research needs to be undertaken to understand the etiology of EED further, existing evidence points to the importance of this condition that seems to take root in very early stages of child growth with consequences for malnutrition, morbidity, and mortality.

Childhood infections increase the risk of death in undernourished children. Olofin et al. (2013) demonstrate the increased risk of death from different infections as the severity of growing deficits increases. According to Olofin et al., the risk of dying from respiratory infection among underweight children ranged x to 10.1 and x to 9.68 among wasted children. The risk of dying from diarrheal diseases was highest with HR ranging from 1.73 in mildly underweight children to 11.56 among severely underweight children and 1.62 in moderately wasted children to 12.33 in severely wasted children (Olofin et al., 2013). Measles increased the risk of death among children with growth deficits with HR of up to 7.73 in severely underweight children and 9.6 in severely wasted while the risk of dying from other infections ranged from 3.01 in severely stunted children to 11.21 in severely wasted children (Olofin et al., 2013). Stunting also increased the chances of dying from childhood infections (HRs ranging from 1.92 to 6.39) although the risk was generally lower compared to the risk posed by underweight and wasting (Olofin et al., 2013). Of the different infections, diarrhea poses the most significant risk of death for undernourished children.

Proximal Causes of Undernutrition

Inadequate Access to Food

Access to food at the household level determines how much food is available for consumption in the household. Access to food depends on the extent to which a household is food secure. According to the Food and Agricultural Organization (FAO) (FAO, 2006), a household or nation is food secure when "all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (p. 1). FAO's widely accepted definition of food security highlights the dimensions of food security, namely food availability, food access, utilization, and stability, which all have implications for the nutrition status of children in a given household. Of these dimensions, the UNICEF conceptual framework of determinants of undernutrition focuses on food access as one of the causes of undernutrition, but several researchers have attempted to elucidate the relationship between the broader concept of food insecurity and malnutrition with mixed conclusions.

Mutisya, Kandala, Ngware, and Kabiru (2015) examined the effect of food security on the nutrition status of urban poor children aged 6-23 months and established that there was a 7 and 12 percentage point increase in stunting between the food secure and either moderate and severely food insecure households respectively. After adjusting for wealth, this study found that children from severely food insecure households were 21% (HR: 1.21, CI: 1.09–1.33) more likely to be stunted than those from food secure households (Mutisya et al., 2015). Mutisya et al. thus concluded that there was a combined effect of wealth and food insecurity that further depressed the nutrition status of children, although this was only significant for the middle and least poor groups. This finding suggests that wealth modifies the effect of food insecurity where wealthier households are more likely to be able to access food that meets their dietary needs compared to less wealthy or poor households that are less likely to have access to necessary foods especially in urban populations that don't produce their own food. However, Singh Abhishek and Singh Ashish (2014) in a different study in Nepal found that the association between food insecurity and malnutrition was independent of household wealth. Ali et al (2013) corroborated this finding and concluded that the association between household food insecurity was to a certain degree independent of household wealth. Singh et al. and Ali et al. nonetheless found food insecurity was associated with stunting similar to what was established by Mutisya et al. (2015).

Ali et al. (2013) conducted their study in Ethiopia, Bangladesh, and Vietnam where they established that moderate and severe food insecurity were significantly associated with stunting and underweight in all the countries and with wasting in

Bangladesh and Vietnam after adjusting for confounding factors except wealth. However, the level of of significance reduced when wealth was controlled. Singh et al. (2014) also established that children from severely food-insecure households and moderately food-insecure were 1.50 (95% CI, 1.15 to 1.97) times and 1.40 (95% CI, 1.08 to 1.80) times likely to be stunted compared to children from food secure households. Additionally, children from severely food-insecure households were significantly more likely to be underweight than children from food-secure households (odds ratio, 1.40; 95% CI, 1.05 to 1.85) (Singh et al., 2014). Similarly, Saaka and Osman (2013) in a study in Ghana established that children in food secure households were 46% protected from chronic malnutrition (OR, = 0.54 95% CI: 0.31–0.94) compared to children in food-insecure households with the association being stronger among children that were at least 23 months. Saaka and Osman also found that household wealth influenced the relationship between household food security and stunting contrary to findings by Singh et al. and Ali et al. but in agreement with Mutisya et al. (2015).

Low social, economic status, and poverty are likely to increase undernutrition by limiting the ability to access food, especially in households that depend on food purchases. The study by Saaka and Osman (2013) revealed that food security measured by a Food Consumption Score (FCS) had strong correlations with household wealth index. Egata, Berhane, and Worku (2013), Egata et al.(2014) and Kinyoki et al.(2015) showed that poverty and poor access to food were significantly associated with wasting while Rannan-Eliya et al. (2013) and Kismul, Acharya, Mapatano, and Hatløy (2017) showed that poor access to food was significantly associated with stunting. However, others argue that it is the care and feeding practices, not wealth that influences the nutrition status of children (Abate & Belachew, 2017). Wong et al., (2014), on the other hand, observed that food access exacerbated by increasing food prices was a more significant problem for household nutrition than food availability in Terengganu, Malaysia. The relationship between food security, poverty and undernutrition is intricate but one that can be scrutinized based on the dimensions of food security (availability, access, utilization, and stability) to get a better understanding of how it manifests in different contexts.

Existing evidence on the relationship between food security and undernutrition is mixed with some evidence suggesting that they are related and other evidence indicating that they are not associated. A study conducted in rural Cambodia established that household food security was not associated with child stunting or wasting rather maternal thinness (McDonald et al., 2015). An earlier study by Osei et al., (2010) also did not find a significant relationship between household food security and stunting, underweight, wasting or anemia among children aged 6 to 23 months but found that social, economic status was associated with household food insecurity, stunting, underweight, and anemia. A different study conducted in Ethiopia by Motbainor, Worku, and Kumie (2015) found that food insecurity was only significantly associated with wasting and not stunting or underweight. According to Motbainor, Worku, and Kumie (2015) food diversity and the number of meals that a child ate per day were instead the significant determinants of stunting and underweight respectively suggesting that the variety of nutrients in the food and the frequency of meals were more critical factors in determining nutrition status rather than just availability and access to food. Osei et al. on the other hand argue that while food security was crucial in determining the availability of food in the household, other household level factors such as feeding practices, maternal education, and social, economic status were important in determining the nutritional status of children. The arguments by Motbainor, Worku, and Kumie and Oei et al. highlight the need to understand the different pathways through which food security may affect the nutrition status of children. Household food insecurity may lead to rationing of food amounts, limited diversity of foods available in the household and reduced meal frequency which, will all lead to inadequate dietary intake for children and in the long run affect their nutritional status.

The effect of other factors that interact with food security to cause undernutrition may explain the mixed evidence on the relationship between food security and undernutrition. However, there are significant methodological differences in studies that generate this evidence that may also explain the contradictory conclusions. One methodological difference is in the tools that are used to measure household food security. While majority of the reviewed studies used the Household Food Insecurity Access Score [HFIAS] there were variations in the application of the HFIAS tool with regard to the number of questions asked and the recall period. The HFIAS is a tool developed to assess food security based on nine questions over a recall period of 4 weeks (Coates, Swindale, & Bilinsky, 2007). Only the McDonald et al. study applied the tool with 9 questions over a recall period of 4 weeks; the other studies used a different number of questions with a different recall period (Ali et al (9 questions, 30days recall); Singh et al (7 questions, 12 months recall); Saaka and Osman (9 questions, 30 days recall; Osei et al. (5 questions, 12 months recall). Mutisya et al. used the Radimer framework to measure food insecurity while Saaka and Osman used the Food Consumption Score [FCS] and Household Dietary Diversity Score [HDDS] besides HFIAS but notably did not find HFIAS to be significantly related to undernutrition rather FCS and HDD as the significantly related measures.

With different tools used to measure food security and adaptations in the application of the HFIAS, the studies are bound to have mixed results that are not comparable. In a review of tools used to assess food security, Jones, Ngure, Pelto, and Young, (2013) observed that there is a wide range of tools with different conceptualizations of food security. According to Jones, Ngure, Pelto, and Young, a researcher's choice of a tool is subject to the food security domain of interest (food availability, food access, utilization, stability), the purpose of the study (for example early warning, targeting food aid, advocacy), the period of interest (chronic or season), the level of measurement (individual, household, regional, national) and the resources available to undertake the study. It is also important to note that besides the differences in the tools used to measure food security, there are also differences in the age groups of the population studied to assess undernutrition. The studies reviewed used age ranges of 623 months, 6-36 months, 6-48 months and under 5 with the mean ages based upon which conclusions were made varying considerably between the studies. What emerges from existing literature on the association of food security and undernutrition is the lack of methodological consistency in studying the association across populations and geographies that needs to be addressed. Additionally, existing evidence points to the need for a better understanding of the pathways through which food security affects the nutrition status of children in different contexts to implement contextually appropriate interventions.

Infant and Young Child Feeding Practices

Proper feeding and care practices will protect children from undernutrition by increasing nutrient intake and minimizing the chances of infection. WHO and UNICEF recommend early initiation of breastfeeding within 1 hour of birth, exclusive breastfeeding for the first six months of life (180 days) and introduction of nutritionally-adequate and safe complementary (solid) foods at six months together with continued breastfeeding up to two years of age or beyond (WHO, 2009). However, many infants and children do not receive this level of age-appropriate feeding. WHO (2016) estimates that only about 43% of the world's children aged between 0-6 months are exclusively breastfed while in most countries, less than 25% of children aged 6-23 months are fed with age-appropriate diet diversity and frequency. WHO and UNICEF continue to engage stakeholders in promoting IYCF in line with the global IYCF strategy. The global IYCF strategy calls for development and implementation of IYCF policies, supporting mothers to adopt appropriate practices, empowering health workers to provide IYCF services and enacting policies that protect breastfeeding rights of women and cub the marketing of breast milk substitutes (WHO, 2003). Several countries including Somalia have gone ahead to develop country specific IYCF strategies to guide the promotion IYCF as a crucial strategy for safeguarding the health and development of future populations.

Breastfeeding Practices

The WHO and UNICEF prescribe three indicators for assessing proper breastfeeding; early initiation of breastfeeding, exclusive breastfeeding under six months and continued breastfeeding for one year (WHO, 2007). Breastfeeding strengthens children's immunity and protection from infections like diarrhea and pneumonia (Hanieh et al., 2015; Quigley, Carson, Sacker, & Kelly, 2016). Diarrhea is a major cause of premature death in infants and increases chances of undernutrition in children. There is extensive evidence on the effectiveness of breastfeeding in protecting children from undernutrition, although there are different arguments over the length of the breastfeeding period. Several studies have established that breastfeeding reduces the odds of wasting and underweight (Fekadu et al., 2015; Egata et al., 2014) while others have found that breastfeeding reduces chances of being stunted. Further, Rachmi, Agho, Li, and Baur, (2016) found that initiation of breastfeeding within an hour of birth significantly reduced chances of underweight, although they did not find a significant relationship between exclusive breastfeeding and stunting or underweight. However, Marriott, White, Hadden, Davies, and Wallingford, (2012) found that breastfeeding among children aged 12-15 increased the likelihood of being underweight. Rachmi et al. (2016) found that breastfeeding beyond six months increased the chances of being stunted or underweight. Aheto, Keegan, Taylor, and Digg (2015) and Akombi et al. (2017) argue that prolonged breastfeeding competes with complementary foods and could be the cause for an increase in the risk of underweight and stunting among children that are breastfed for a long time. These findings put into question the length of breastfeeding that is beneficial to children, although there doesn't seem to be sufficient research to answer that question.

Studies on interventions that would work to reduce undernutrition globally have identified breastfeeding as a critical intervention. According to Bhutta et al. (2013) promotion of breastfeeding is one of the ten interventions that if implemented at 90% coverage show 20·3% (range 10·2–28·9) reduction in stunting and a 61·4% (35·7–72) reduction in severe wasting. Further, of the ten interventions, promotion of breastfeeding is one of the three interventions with the most enormous potential effect on reducing mortality in children under the age of five alongside management of severe acute malnutrition and preventive zinc supplementation (Qar et al., 2013). The importance of breastfeeding in protecting children from mortality and morbidity has placed it among global nutrition targets where WHO's Member States have committed to increasing the rate of exclusive breastfeeding to at least 50% by 2025 (WHO, 2014a). Commitment to achieving this goal will be a significant contribution to ensure survival and development of children.

Complementary Feeding Practices

Complementary feeding refers to feeding children ages 6-23 months with safe and nutritious foods. WHO and UNICEF use indicators such as introduction of solid, semi-solid foods or soft foods at the age of 6-8 months, minimum dietary diversity (6-23 months), minimum meal frequency (6-23 months) and minimum acceptable diet (6-23 months) to assess infant and young child feeding practices globally. In a study of WHO infant and young feeding indicators using data from Demographic health surveys in 14 low-income countries Marriott et al. (2012) established that consumption of solid foods in 6-8 months' children and dietary diversity (6-23 months) were associated with a significantly lower risk of both stunting and underweight. The same study established that feeding frequency was significantly associated with underweight but not stunting while consuming a minimum acceptable diet was also associated with a lower overall probability of underweight ($P < 0.01$) and stunting ($P < 0.01$). Similarly, Menon, Bamezai, Subandoro, Ayoya, and Aguayo, (2015) in a study of feeding practices in India established that timely introduction of solid foods reduced the chances of underweight while diet diversity and minimum acceptable diet reduced the odds of stunting and underweight.

Other studies that have investigated the effect of providing complementary foods to children reveal significant weight gain among children that receive complementary foods. In a pooled analysis of several studies on complementary feeding, Lassi et al., (2013) found a significant impact of complementary food with or without education on HAZ and WAZ scores and a significant reduction of underweight (RR 0.35; 95% CI: 0.16, 0.77) but not stunting. Notably, this analysis did not include studies in which complementary feeding was provided for supplementary and therapeutic purposes. Similarly, Dong et al. (2013) found a reduction in prevalence of wasting (3.5% to 1.7%), stunting (8.9% to 5.0%) and underweight (4.5% to 3.3%) after 18 months of following a population where all resident children in villages of Kang county of China were given a daily supply of complementary food supplements.

The benefits of IYCF in protecting children from undernutrition are well documented, and they underpin IYCF promotion activities; however, the adoption of IYCF practices remains globally suboptimal. Several researchers have sought to understand the factors that influence the adoption of IYCF practices in different contexts. In a study conducted in Uganda, Nankumbi and Muliira (2015), established that care giver's knowledge about breastfeeding and complementary feeding, the influence of key family or community members on caregivers and demands of other responsibilities on caregivers affect the adoption of IYCF practices. In Dhaka slums, Kabir, Rose, and Maitrot (2017) also established that while mothers were knowledgeable about appropriate infant feeding practices, they traded time that would be allocated to preparing nutritious food and feeding their infants to meeting work demands. Mothers in this study were found to leave children in the care of other siblings and caregivers like grandmothers while they went to work, but these caregivers did not have any knowledge on nutrition or hygiene. This practice not only leaves children feeding on poorly prepared food or purchased food with little nutritional value but also leads to early introduction of solids to breastfeeding children, which all jeopardize the nutrition status of children. As a fact, Marriott et al., (2012) established that the timely introduction of solids had the most significant association with underweight and stunting among IYCF indicators studied across 14 low-income countries.

The level of maternal education is another factor that influences the adoption of appropriate feeding practices where mothers with higher education are more likely to provide complementary feeding at the right time and are more likely to provide minimum acceptable diets compared to mothers with less or no education (Gautam, Adhikari, Khatri, & Devkota, 2016). Marriott et al. (2012) also found an interaction between maternal education and several IYCF indicators suggesting that the IYCF practices protected children from undernutrition but significantly so among educated mothers than in mothers without education. Household food insecurity in terms of food availability and access, which are exacerbated by food prices, also limit mothers' ability to provide required diet diversity and meal frequency (Brown et al., 2016). While IYCF practices protect children from undernutrition, several factors influence the adoption of the practices, which nutrition program designers and implementers need to establish and consider in program design and implementation.

Water, Sanitation, and Hygiene

Poor water, sanitation, and hygiene conditions increase vulnerability to infections in children, which affect their survival and development. WHO & UNICEF (2017) estimate that of people that used surface water for drinking purposes in 2015, 58% lived in sub-Saharan Africa, while only 28% have access to basic sanitation services with most countries having less than 50% coverage of necessary handwashing facilities. These statistics show a low level of access to proper water, sanitation, and hygiene facilities in sub-Saharan Africa, which puts millions of children at the risk of infections and undernutrition.

Several studies have documented the association between poor water, sanitation, and hygiene practices and undernutrition.al studies. Rah et al. (2015b), in a study on household sanitation and child stunting in India, found that in households with access to a toilet facility, children had 16% lower chances of being stunted compared to children in households that practiced open defecation. The same study established that caregiver's reported practice of washing their hands with soap after defecation and before handling food was associated with a 14% and 15% reduced risk of stunting among children aged 0–23 months. Nguyen et al. (2017) also established that in Bangladesh and Vietnam, hygiene was significantly associated with HAZ ($\beta = 0.060$ for Bangladesh and 0.054 for Vietnam) explaining 19% and 10% of the changes in HAZ (respectively) in a food security and nutrition program implemented between 2010 and 2014. Further, several researchers argue that reduction in open defecation in Bangladesh and Nepal are plausible explanations for the rapid decrease in stunting that the two countries have achieved (Headey, Ali, Tesfaye, Dereje, & Hoddinott, 2015) and (Headey & Hoddinott, 2015).

Research has endeavored to elucidate pathways from poor water, sanitation, and hygiene to undernutrition. Diarrhea is one of the ways through which the poor water, sanitation, and hygiene are understood to influence undernutrition in children. However, some scholars have argued that infections of the gut in children could be a more plausible way in which poor water, sanitation, and hygiene influence undernutrition. Humphrey, (2009) argued that studies on the effect of interventions to improve nutrient intake did not show enough growth increase to cover deficits observed in African and Asian children while studies on diarrhea, suggested that children could catch up in their growth in between diarrhea episodes implying that there was another factor that explains the growth deficit. Humphrey, therefore, suggested that tropical enteropathy or Environmental Enteric Dysfunction (EED) a disorder that disrupted normal functions of the small intestines was the critical cause of undernutrition and related growth failure. He also suggested that “tropical enteropathy and not diarrhea is the primary causal pathway from poor sanitation and hygiene to undernutrition (Humphrey, 2009. pg 1032).

According to Mbuya and Humphrey (2016), when children living in contaminated environments ingest microbes, the gut structure and function are altered, leading to poor digestion and absorption of nutrients as well as damage of the intestinal barrier function which then allows germs to circulate further leading to an inflammatory response. Continued exposure to germs leads to diversion of nutrients to infection-fighting rather than supporting growth, suppression of growth hormones, and further damage to the intestinal mucosa (Mbuya & Humphrey, 2016). Children may ingest of microbes through drinking unsafe water that is contaminated with fecal bacteria, eating without their washing hands or being fed by caregivers that don’t wash their hand after defecation or before feeding as well as eating soil and other contaminated objects in their normal play and exploration. Interruption of the oral transmission of fecal bacteria can be achieved through improving water, sanitation, and hygiene conditions in households.

Distal Causes of Undernutrition

While there is more research and evidence to support the proximal causes of undernutrition, there is limited evidence on the effect of distal factors. Distal factors in the form of broad social and structural issues impact the proximal causes of malnutrition.

Referring to social and structural issues as social determinants of children's survival and development, Bell et al., (2013) propose an analytical framework for understanding social determinants that policymakers can use to move beyond the focus on proximate causes of poor health and nutrition in children.

According to an analytical framework by Bell et al. (2013), social determinants exist at three levels: the macro level context, the wider society, and the systems level. At the macro level, there are political, economic, social, environmental and historical, cultural norms and values, governance and human rights, violence and armed conflict issues that affect access to resources that caregivers need to meet nutrition needs for their children (Bell et al., 2013). At the broader social level, there are issues such as gender biases and discrimination based on ethnicity or race which also affect caregiver’s ability to achieve the best possible nutrition outcomes for their children (Bell et al., 2013). In addition to the macro and broader social issues, there are systems such as education, health, and employment that have an impact on the knowledge and resources that caregivers have to meet children’s nutrition needs (Bell, Donkin & Marmot, 2013). With a similar outlook on distal causes of undernutrition, the World Bank (2013) observes that results from actions to address proximate causes of malnutrition are enhanced by addressing distal factors.

National Income

National income affects children’s nutrition by enabling the availability of public services at the society level and household level by allowing the availability of resources to meet nutritional needs like food, water, and medical care. Countries that have higher national income can provide quality services to the population while individuals in such countries can meet children's nutritional needs; developing countries, on the other hand, are not able to provide services while their people live in poverty unable to meet basic needs. National income has been shown to have an inverse relationship with child mortality emphasizing its importance as an upstream health determinant (Hare, Makuta, Chiwaula, & Bar-zeev, 2013). However, high national income that is poorly distributed breeds inequality, which has poor implications on population health. On the subject of the distribution of national income, Wilkinson and Pickett (2010) argue that it is not how wealthy a society is that determines health rather how well wealth is distributed in that society.

In their study of undernutrition, drivers in the post MDG era, Smith and Haddad, (2015) established a significant effect of national income on child stunting with estimates of a 10% increase in per-capita GDP resulting into a 6.3% decrease in the stunting prevalence over time. Income contributes to reducing stunting by enabling access to sanitation, increasing women's access to formal education, and increasing the availability of the quality of food in the households Smith and Haddad (2015). Wu, Yang, Yin, Zhu, and Gao, (2015) also established that stunting and underweight prevalence in China between 1990 to 2010 was negatively associated with GDP per capita ($p<0.01$) concluding that socioeconomic growth played a significant role in reducing malnutrition in the country. Interventions that facilitate the increase of household income, economic policies that enable national income growth, and equitable allocation of resources from increased national revenue could lead to progressive improvement in child nutrition in many low and middle-income countries.

Conflict and Violence

Conflict disrupts food production, the functioning of markets, access to services, and human settlement which distress household level conditions of food security, care for children, and the health environment that are immediate causes of undernutrition. Studying the impact of conflict in Sri Lanka, Johnson (2017) found that the pace of reducing infant mortality slowed down during the years of war with some districts reporting malnutrition as a primary cause of death. Likewise, Moore et al. (1993) observed that armed conflict made it impossible to implement immunization and community health worker programs that could have prevented the high mortality rates due to measles and diarrhea during the 1992 famine in SCS.

Conflict weakens government systems, public services, and democratic processes Sousa (2013). Public health utility systems and physical infrastructure are either neglected or destroyed in war affecting quality and access to health and nutrition services. Further, conflict undermines governance systems and aggravates corruption that weakens the government's ability to ensure health and well-being of the population. Studying the impact of the 2002-2007 armed conflict in Côte d'Ivoire on children’s health Minoiu and Shemyakina (2014), found that children who lived in conflict-affected areas had height-for-age z-scores that were lower than children that lived in areas not affected by conflict. Minoiu and Shemyakina also found that household economic losses experienced during war impacted child health the most but other mechanisms such as displacement, poor physical or mental health of caregivers and violence experienced within the household were also important factors. Likewise, Kinyoki et al. (2017) demonstrated that in Somalia, conflict increased the odds of wasting by 1.37 times and stunting by 1.21 times while longer-term conflict almost doubled the odds of both wasting and stunting.

Conflict exasperates the effect of other natural disasters on the health and nutrition wellbeing of populations. Tranchant, Justino, and Müller (2014) for instance demonstrated that in Andhra Pradesh, India, the effect of drought on child nutrition was higher in areas affected by conflict compared to areas that did not experience conflict. According to Tranchant et al., the impact of conflict on child nutrition was due to reduced economic coping strategies and reduced access to services and goods in the areas affected by conflict. Further, Tranchant et al. established that an eight-month ceasefire resulted in reduced levels of undernutrition (HAZ), leading to a conclusion that drought has a long-term effect on nutrition outcomes when it interacts with conflict. In Somalia, the impact of the 2011 famine on adult and child mortality was exacerbated by a conflict that limited access to essential services and displaced populations in affected areas (Checchi and Robinson,2013; Maxwell & Fitzpatrick, 2012). Evidence on the effect of conflict on undernutrition suggests a need for targeting conflict-affected populations with interventions that mitigate its impact on access to services and social, economic factors to protect children from the risks of undernutrition.

Ethnicity

Gender inequalities and discrimination based on race or ethnicity influence nutritional outcomes for children and may explain the disparities in undernutrition in different contexts. Exclusion from full participation in social affairs limits the quantity and quality of resources that caregivers have to meet survival and development needs of children. Brcanski, Jović-Vraneš, Marinković, and Favre (2014) studied the association between social determinants of health and growth indicators among Serbian children aged five years and established that ethnic minority Roma children were almost three times more likely to be stunted and twice more likely to be severely stunted than non-Roma children. Brcanski et al. (2014) argue that even after adjusting for sex, age, mother's education, region and type of settlement, Roma children were more likely to be stunted than non-Roma children in the lowest wealth quintile concluding that ethnicity was a significant predictor for stunting among Serbian children.

There are also several arguments on the role of ethnicity in the famine crisis in Somalia that resulted in nutrition-related morbidity and mortality. According to Majid and McDowell (2012), the 1991 and 2011 famine crisis in Somalia predominantly affected minority clans as a result of long-term marginalization that affected their livelihoods and coping mechanisms. Kinyoki et al. (2016) also observed that compared to other areas of Somalia, the prevalence of wasting over four years (2007 -2010) was persistently high in Gedo and Bay. Minority clans predominantly occupy Bay and Gedo areas. Marginalization based on ethnic backgrounds affects the level of access and quality of resources that households have to care for children and therefore, their ability to protect them from the risk of malnutrition.

Gender

The effect of gender inequality on nutrition outcomes in children is mainly through child care and feeding, which, is an essential proximate predictor of undernutrition. The quality of child care and feeding depends on caregivers' level of knowledge of feeding practices (Nankumbi & Muliira, 2015) and the amount of time that caregivers allocate to child care and feeding (Kabir et al., 2017). The quality of care and feeding also depends on mother's level of education (Marriott et al. 2012) and resources that determine availability and quality of food (Mutisya et al., 2015). However, gender inequality in several contexts leads to women that have lower educational and employment opportunities, higher levels of workload, lower levels of decision-making, and control over assets and experience higher levels of domestic violence. Despite these limitations, women have a greater responsibility for child feeding and feeding. These gender-based disadvantages have an impact on the quality of child care and feeding and therefore, children's nutrition outcomes. In India, Imai, Annim, Kulkarni, and Gaiha, (2014) demonstrated that women’s empowerment had a positive impact on child nutrition status. Cunningham et al., (2015) also established that in rural Nepal, women’s empowerment in agriculture especially in regard to autonomy in production decisions, satisfaction with time available for leisure activities, and access to and decision making regarding credit were significantly associated to nutrition status in children under the age of two. This evidence suggests that reducing child malnutrition requires addressing gender inequalities. Kerr, Chilanga, Nyantakyi-Frimpong, Luginaah, and Lupafya (2016) examined this proposition in a rural Malawi community and established that through community education activities targeting both men and women, society gender norms that affect child care could be shifted leading to better child care and feeding practices in the household. Kerr et al. (2016) further enumerate that availability of the right quality and quantity of food in the family is not enough to impact nutrition if there are gender biases that influence child care, resource control and decision making in the household. International Food Policy Research Institute, (2012) also put forward a similar argument that increasing agricultural productivity will only have an impact on child health and nutrition if gender equity is built into strategies for agricultural development.

The effect of gender equality in reducing undernutrition is of significance in the SDG era. Studying the drivers for reducing malnutrition between 1970 and 2012, Smith and Haddad (2015) established that women's education, gender equality, and food availability at the national level were determinants of child stunting pointing to their importance in efforts to reduce undernutrition beyond 2012. Likewise, Marphatia, Cole, Grijalva-Eternod, and Wells (2016) studying the effect of GDP and Gender Inequality Index [GII] on wasting and stunting in 96 countries established that GII alone explained 10% variance in wasting and stunting and had an inverse relationship with the two outcomes. Further, Marphatia et al. simulated the effect of reducing gender inequality and found it to be most beneficial for the poorest countries. Similarly, Smith and Haddad (2015) observe that improvements in women's education, gender equality national food availability could result in reducing national stunting rates in the post MDG era. Despite the minimal focus on gender equality as a strategy to reduce undernutrition stunting during the MDG era, it presents an opportunity for improving nutrition in the SDG Era.

Politics and Governance

Politics and governance determine governments' ability to effectively implement policies and programs and the ability to create an environment that is economically stable for households to meet children's nutrition needs. In politically unstable states where the government does not have the complete legitimacy to develop and implement policies as well as enforce rules and regulations across its territory, delivery of public health services is affected. For instance, Krasner and Risse (2014) observe that though not impossible, delivery of goods and services in failed states is very limited, especially in the aspects of infrastructure, economic subsistence, and health. Further, political instability hampers economic growth, although poor economic growth itself may trigger political instability (Alesina, Ozler, Roubini, & Swagel, 1996; Okafor, 2015). Political instability will also affect the functioning of markets that are necessary for providing access to nutrition inputs such as food. Concerning governance, the ability of government to formulate and implement policies and regulations that regulate the private sectors on issues such as promoting and marketing food products like breast milk substitutes is key to reducing the risk of childhood undernutrition (International Food Policy Research Institute, 2016). Control of corruption as an aspect of governance is critical in taming abuse of public power and the misuse of resources that lead to the failure of nutrition programs. Smith and Haddad (2015) used a governance index to show that good governance contributes to reducing child undernutrition, although they did not make firm conclusions on the relative effect of specific dimensions of the index.

Further, Gillespie, Haddad, Mannar, Menon, and Nisbett (2013) observed that political commitment and good governance of nutrition at both national and global level is key to creating an environment that will enable a reduction in undernutrition. Mejía Acosta and Fanzo (2012) specifically, suggest that intersectoral collaboration to eliminate duplication of efforts; vertical coordination of nutrition plans that allow local level and national level stakeholders to pursue shared objectives; and funding that is well managed and allocated are vital to ensuring effective nutrition governance.

Rural versus Urban location

Where children live and grow affects their chances of good health and nutrition. Health and nutrition in urban communities are compromised by over congestion, slum dwelling, inadequate shelter; while in rural communities it is compromised by poverty and lack of access to services (WHO, 2008). Across the globe, there is an increase in rural-urban migration that is pushed by low investment in rural infrastructure and services, limited opportunities for economic growth in rural areas, displacement due to war and conflict and the effects of climate change that have disrupted rural livelihoods. Compared to rural households that produce their food, urban populations depend on food purchases which, are highly dependent on market supply, household purchasing power and food prices (Mohiddin, Phelps, & Walters, 2012). As such, urban households with better income have a greater ability to provide nutritionally diverse food that meets children's nutrition needs compared to the urban poor that have limited purchasing power. Studying childhood undernutrition in urban areas, Kumar, Kumari, and Singh, (2015) and Mutisya et al., (2015) reveal that poorer urban households will have a higher prevalence of undernutrition compared to economically better off families. However, the urban lifestyle may affect feeding habits where households consume more “ready-made” fast foods or energy-dense and highly processed foods that are risk factors for obesity. Indeed as much as undernutrition prevails in urban areas there is an observed increase in obesity in both children and mothers leading to the double burden of malnutrition phenomenon (Kimani-Murage et al., 2015; Jones, Acharya, & Galway, 2016).

The prevalence of undernutrition is also high in some rural areas because of factors that may be different from influential factors in urban areas. Studying undernutrition among mothers and children in rural and urban areas of Lagos state in Nigeria, Senbanjo, Olayiwola, Afolabi, & Senbanjo (2013) established that the prevalence of underweight and stunting were significantly higher in rural areas compared to urban areas (OR 3.8, 95% CI = 1.8-8.1, $p < 0.001$ and OR 7.4, 95% CI = 3.8-14.1, $p < 0.001$ respectively). Senbanjo et al. (2013) argued that the higher prevalence of undernutrition in the rural areas could be linked to the higher prevalence of social demographic factors that favor maternal and child undernutrition such as the high number of live children born per woman, lower education level and lower social, economic level. Senbanjo et al. concluded that the risk factors for child undernutrition in the rural communities were more social economic compared to the predominantly biological factors in the urban areas.

Srinivasan, Zanello, and Shankar (2013) demonstrated that differing levels of maternal education, spouse’s education, and household wealth explained the rural-urban disparities of undernutrition in Bangladeshi and Nepal. Srinivasan, Zanello, and Shankar further argue that the rural-urban disparities in nutrition outcomes are mainly explained by the difference in the level of the determinants rather than the strength of the associations between the determinants and nutrition outcomes. Srinivasan, Zanello, and Shankar thus concluded that equalizing opportunities for social determinants of nutrition such as increasing women's education and household wealth in rural areas, and improving rural infrastructure would contribute to eliminating the rural-urban disparity in child nutrition. The findings by Srinivasan, Zanello, and Shankar point to the importance of designing policies and programs that close the gap in socio-economic benefits between the urban and the rural thereby eliminating disparities in nutrition outcomes for children.

Displacement

Population displacement due to drought, floods, armed conflict, violence, and persecution have become a common phenomenon in the world today. The United Nations High Commission for Refugees(UNHCR) (2018), estimates that by the end of 2018, there were 70.8 million people in the forced displacement of whom 41.3 million were internally displaced within their own countries. At the end of 2018, 3.7 million people from Somalia were either internally displaced or refugees or asylum-seekers (UNHCR) (2018). Internally Displaced Populations (IDP) face disadvantages before, during, and after a flight that increases their vulnerability to poor health (Thomas & Thomas, 2004). Before the flight, populations may be poor, have limited access to services, or be marginalized groups, which makes them more vulnerable to the effects of displacement. During the flight, the people may lack food, water and access to health services while upon arrival at their destination, they settle in IDP camps and depend on aid to meet their basic needs like food, shelter, water, sanitation, and health. However, IDP camps are often crowded with poor living conditions and limited provision of basic services available in the hosting communities. IDP populations also struggle to find opportunities in the labor market or viable livelihood opportunities which put a strain on household economic resources, and therefore the quantity and quality of available food. Such disadvantages could explain the high level of morbidity and mortality in IDP populations. In Somalia for instance, World Food Programme (WFP) (2012) demonstrates a persistently high prevalence of Global Acute Malnutrition (above 15% emergency threshold) among IDP settlements compared to a good nutrition status in host communities. Likewise, Checchi and Robinson (2013) observed that the highest mortality during the 2010- 2012 period of severe food insecurity and famine in Somalia was among IDPs. With IDP populations often estimated to have higher proportions of women and children, displacement contributes to increasing vulnerability to maternal and child undernutrition.

System-level Factors

Government systems for education and employment influence the extent to which parents have knowledge and resources that they need to care for children. An education system that enables access to education, especially for girls, is essential in equipping future child caregivers with knowledge and skills that influence their behaviors in caring for children. Studying the effect of parental education on child undernutrition in low and middle-income countries, Vollmer, Bommer, Krishna, Harttgen, and Subramanian (2017) established that both high maternal and parental education reduced chances of childhood undernutrition. Headey and Hoddinott (2015) and Headey et al. (2015) also demonstrated that parental education is a crucial driver in the enigma of nutritional improvements in Nepal and Bangladesh, respectively. Headey and Hoddinott (2015) expressly point out a “sizable” contribution of maternal education in predicting nutritional outcomes for children with an additional year of schooling predicting a 0.06 standard deviation increase in child HAZ (pg 10). Further, Srinivasan et al., (2013) demonstrate a significant association between maternal education and HAZ scores in both rural and urban areas of Nepal and Bangladesh arguing that improving maternal education is especially crucial in bridging the gap in rural-urban disparities on undernutrition.

Research has demonstrated not only an association between maternal education and child undernutrition but also an association with paternal education. Egata et al. (2014) established that paternal illiteracy increased the odds of acute malnutrition by 44% among children in rural Ethiopia. Likewise, Rodriguez-Llanes, Ranjan-Dash, Mukhopadhyay, and Guha-Sapir (2016) revealed that paternal schooling had effects of protecting 6–59 months age children from wasting and stunting in a post-flooding study in Jagatsinghpur district, Odisha (India). Rodriguez-Llanes et al. (2016) found that paternal schooling had more effect than maternal education, an observation that they related to the minimal economic independence of the mothers in their sample, which could have affected their role in meeting children's nutrition needs. Headey and Hoddinott (2015) also established that paternal education had a significant effect on severe stunting (HAZ<–3) though it had a weak impact on moderate stunting (HAZ<–2). Vollmer et al. (2017) also observed that while higher maternal education had a stronger association with lower undernutrition than paternal education, controlling different factors that could influence the relationship weakened the relationship suggesting that paternal education was equally important. The evidence on the effect of parental education on undernutrition demonstrates that investment in education systems to allow universal access to education would contribute to achieving better nutrition outcomes for children.

The functionality of government health systems also determines the extent to which the population has access to health care and public health services that can protect children from undernutrition. Egata et al. (2014) established that in eastern rural Ethiopia, lack of maternal access to health service facilities significantly increased the odds of acute undernutrition among children aged 6 to 36 months. Headey and Hoddinott (2015) also suggest that increases in access to health care in Nepal contributed to the drastic reduction in undernutrition between 2001 and 2011. According to their analysis, health care contributed 22% and 18% to the predicted change in moderate and severe stunting, respectively (Headey & Hoddinott, 2015). Investigating the rapid reduction of undernutrition in Asian countries Bangladesh, Headey et al., (2015) and Headey and Hoddinott, (2015) posit that countries like Nepal and Bangladesh have been successful because of government investment in education and health systems alongside public health campaigns. According to Headey and Hoddinott, the government of Nepal made significant investments in the community health extension network and provided financial incentives, which all contributed to an increase in antenatal, neonatal, and postnatal services. Headey et al., (2015) argue that in Bangladesh, education gains that are associated with the reduction in undernutrition are linked to government's programs such as the secondary school stipend for girls. Policy changes drive public investments in education and health; the Nepal and Bangladesh experiences demonstrate the potential of achieving a reduction in child undernutrition by tackling structural issues beyond household behavioral issues.

Addressing Causes of Undernutrition

Black et al. (2013) proposed a conceptual framework of actions to achieve optimum fetal and child nutrition and development. The framework is premised on addressing immediate, underlying, and basic causes of undernutrition. According to this framework, immediate causes of undernutrition are addressed through nutrition-specific interventions and programs while the underlying causes of undernutrition are addressed through nutrition-sensitive programs and approaches. The framework adds that an enabling political and policy environment is required to support interventions and programs aimed at reducing undernutrition.

In light of the fact that undernutrition underlies the death of about 3.1 million children annually, evidence suggests that ten nutrition-specific interventions could result in reducing under-five mortality by 15% if delivered with 90% coverage in countries with the highest burden on undernutrition (Bhutta et al., 2013). The ten recommended interventions are: peri- conceptual folic acid supplementation or fortification, maternal balanced energy protein supplementation, maternal calcium supplementation, multiple micronutrient supplementation in pregnancy, promotion of breastfeeding, appropriate complementary feeding, vitamin A and preventive zinc supplementation in children 6–59 months of age, management of SAM (Bhutta et al., 2013). Further, Bhutta et al. (2013) established that of the ten interventions, management of SAM, preventive zinc supplementation, and promotion of breastfeeding had the highest prospective effect of reducing child mortality.

The conceptual framework of actions to achieve optimum fetal and child nutrition and development highlights the importance of nutrition-specific interventions in addressing immediate causes of poor growth and points to the potential of nutrition-sensitive programs in addressing underlying determinants of malnutrition (Black et al., 2013). Ruel and Alderman (2013) examined evidence on the effectiveness of nutrition-sensitive programs in the sectors of agriculture, social safety nets, early child development, and schooling. Ruel and Alderman found positive effects of parental education and early child development programs but inconclusive evidence from agricultural programs except for bio-fortification of vitamin A in orange sweet potatoes and week evidence for social safety nets. Ruel and Alderman, however, note that the evidence examined was generated from programs that were not explicitly designed to improve nutrition, concluding that stronger research in programs with specific nutrition goals will produce better evidence. Nonetheless, Ruel and Alderman concluded that with proper targeting, clear nutrition goals, conditionality for participation, and women's empowerment, nutrition-sensitive programs have the potential to increase benefits from nutrition-specific interventions.

The effectiveness of both nutrition-specific and nutrition-sensitive interventions is dependent on having a supportive environment that comprises the distal causes of undernutrition. Gillespie et al. (2013) argued that addressing political and policy processes that shape the context in which nutrition interventions are developed and implemented is critical to achieving success in reducing undernutrition. Likewise, Bell, Donkin, and Marmot (2013) observed that the impact of interventions to reduce malnutrition could be far-reaching if there is political commitment, multisector collaboration, stronger governance, stronger leadership, willingness to redistribute power and resources and long-term planning. Action on distal causes of undernutrition also addresses issues of disparity, allowing benefits to be equitably enjoyed across the population.

The multisectoral nature of factors that cause undernutrition calls for multi-sectoral approaches. The World Bank (2013) argues that a multi-sectoral approach would accelerate the effect of direct interventions to address undernutrition, expand the opportunity of incorporating nutrition into other sectors and allow better consistency of national policies and strategies on nutrition. Success in tackling undernutrition will therefore not come from a single sector acting alone, rather several sectors each playing its role in addressing a determinant or several determinants of undernutrition whether it is at the child, household, community or national level.

Summary

In this chapter, I presented the literature that exists on undernutrition in children concerning this study. Built around the UNICEF conceptual framework of determinants of undernutrition, the literature shows evidence of the influence of different factors on undernutrition whether at an individual child, household, or society level. The literature also indicates that while evidence on the factors that cause undernutrition in children has been studied widely, no single study has thoroughly examined the relationship between child, household, and society level factors and undernutrition as conceptualized in the UNICEF conceptual framework of determinants of undernutrition in the context of Somalia. The evidence leaves a gap in the knowledge of factors that are most relevant at different levels and the most critical level at which interventions and policies to address undernutrition should focus. The literature further reveals that studies on childhood undernutrition in Somalia have not examined trends in the prevalence of undernutrition or its predictors despite the long period over which undernutrition has been a problem. This study analyzes secondary data to understand trends and predictors of undernutrition in SCS, as described in Chapter 3.

Chapter 3: Research Method

Introduction

The main purpose of this study was to examine trends in prevalence and predictors of undernutrition in the context of SCS. I investigated predictors of undernutrition at the individual child, household, and society level of influence. I also examined trends in terms of prevalence of significant predictors on undernutrition. In this chapter, I describe the research design and methodology, which includes a description of study participants, sampling procedures, data collection instruments, data analysis procedures, and ethical considerations. I also describe threats to validity and how they were managed.

Research Design and Rationale

This study used a quantitative study design to examine the relationship between different factors that influence undernutrition among children in Somalia. Quantitative studies are suitable for studies in which relationships between variables can be examined to test theories and draw conclusions (Creswell, 2009). The study adopted a cross-sectional survey research methodology in which secondary data collected by the Somalia FSNAU from nutrition surveys were analyzed to examine trends and predictors of undernutrition. The cross-sectional survey methodology was used in this study because of its appropriateness for studies that seek to explain the frequency of health characteristics at a particular point in time. Nutrition surveys in Somalia are conducted every year during two strategic dates in the Somalia seasonal calendar to determine the nutritional status of the population at those particular points. Since the year 2000, FSNAU has implemented a food security and nutrition surveillance project, collecting and analyzing data on nutrition, food security, climate, and markets that will give insights into trends of prevalence and predictors of undernutrition in the country.

This study used secondary data. Secondary data has the advantage of providing large sample sizes for variables of interest over a long period of time, enabling secondary data analysis to answer strategic questions (Smith et al., 2011). The FSNAU database provides data collected from large samples with relevant measures for nutrition that made secondary data analysis the most appropriate mechanism for answering the research question. Secondary data analysis was deemed to be both cost and time saving in terms of answering the research question and generating information that is currently required to inform nutrition programming and policy development in Somalia.

Quantitative research designs are appropriate for research problems that seek to establish factors that influence an outcome or to understand the best predictors of an outcome (Creswell, 2009). The quantitative research design was thus most suitable for a study seeking to establish trends in terms of prevalence and predictors of undernutrition. A nonexperiential research methodology was chosen for the study because there was no specific treatment that was administered to the study population to determine causes of undernutrition; rather, there was an analysis of the relationship between different factors and undernutrition. Conclusions from this study, therefore, involve trends of prevalence and predictors of undernutrition, not causes of undernutrition among children in Somalia.

Methodology

This study used data on children's nutrition status collected by the FSNAU through biannual nutrition surveys. The nutrition surveys are conducted following guidelines developed and updated by the Somalia nutrition working group under the coordination of FSNAU. Data that were used in this study was collected following the 2006 and 2011 nutrition survey guidelines. Survey implementation procedures are similar in both guidelines except that the 2011 guidelines have a stronger rigor that is based on the Standardized Monitoring and Assessment of Relief and Transitions (SMART) methodology.

SMART is a survey method that was developed to standardize nutrition and mortality surveys in emergency contexts and for surveillance purposes (SMART, n.d.). The methodology has provisions for data quality verification, protocols for sample size calculation, cluster and household section techniques, and programming software called Emergency Nutrition Assessment (ENA) that does sample size calculations, sample selection, quality checks, and standardization of anthropometry measurement automatically. The SMART methodology allows collection and analysis of consistent and reliable data.

FSNAU works with organizations that implement nutrition programs in Somalia to check for bias in the selection of clusters and households as well as the quality of data. Prior to confirming final survey results, FSNAU shares preliminary surveys results with local authorities and community representatives for validation. Final survey results are confirmed by the nutrition cluster which, is an emergency nutrition coordination group that is composed of UN agencies, and international and national non-governmental organizations.

Study Participants

Participants in this study are children aged 6-59 months and mothers of the children or responsible caregivers where mothers were absent. This study's participants participated in nutrition surveys from 2007 to 2012 in SCS. In this study, SCS covers the regions of Galgadud, Hiran, Bakool, Gedo, Bay, Middle Shabelle, Lower Shabelle, Lower Juba, and Middle Juba as mapped in the United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA) administrative map of SCS.

Sampling and Sampling Procedures

Nutrition surveys conducted over the planned study period used a cluster sampling methodology that is highly recommended for the Somalia context because accurate population figures for large geographical areas are non-existent. Also, the cluster sampling method is recommended where a list of households is difficult to construct, as is the case in Somalia. The cluster sampling methodology is applied in two stages where 30 clusters or villages are randomly selected in the first stage, and then 30 households from which children aged 6-59 months are assessed are randomly selected. The nutrition survey guidelines provide strict procedures for minimizing bias in replacing original clusters and households that may not be reached during the course of the survey for various reasons.

Data Collection

This study used data collected during two seasonal food security and nutrition assessments: the post-Gu (April-June) and post-Deyr (October-December) assessments. FSNAU collaborates with different agencies and organizations to conduct surveys across the country. Before beginning of each seasonal survey, a technical partner planning meeting is held for all participating partners to review the seasonal assessment instruments and plan and coordinate field data collection. The technical meeting finalizes the survey instruments and sends them to field sites in Somalia. At the field level, respective agencies and organizations hold planning meetings to train enumerators on application of the survey instruments after which data collection commences. The unstable security situation in Somalia often limits access to some study populations and may affect the quality of the data; this limitation is taken into account due to consideration during data analysis and is further discussed under limitations.

Instruments and Materials

A standard nutrition household questionnaire in the Somalia nutrition survey guidelines is used for the seasonal survey. While technical experts may make some revisions on the questionnaire, questions relating to household and child characteristics, child feeding, anthropometric indicators, morbidity, food consumption, and dietary diversity, access to water, sanitation, and health facilities are maintained as core in every nutrition survey as per the nutrition survey guidelines.

Data Processing

Data Extraction and Consolidation

Nutrition surveys are conducted per livelihood zones where a livelihood zone is a homogenous area where households have common household economy characteristics. A livelihood zone is the survey area from which a representative sample is drawn for each of the surveys. Upon completion of the surveys, FSNAU validates the data and compiles it into a single data set for a seasonal analysis. This study extracted data collected over six years from clusters or villages that are within the SCS area and merge it into a single dataset for analysis. Identification of relevant clusters was based on the UN OCHA administrative map of SCS.

Data Cleaning

This study had a detailed procedure for cleaning the data. One of the main steps was filling gaps on household level data for all children in individual households because in the nutrition surveys, household data recorded for one child in each household. This process involved matching the cluster number, questionnaire number, household number, and the child number and where such details matched, the information collected for the first child in the household was the same for all the other children in the household. Where information on cluster number, questionnaire number, household number, and the child number were inconsistent, the missing data was not filled in to avoid errors.

Recording New Variables

Data analysis included the creation of new variables for two purposes. The first purpose was to attain consistency in the variables where some survey questions varied in the number of response options for variables like source of income, source of water, and latrine type. New variables were created with the same number of response options for the variables to be consistent. The second purpose for generating new variables was to create new variables that were computed using data from existing variables, for example, wasting, stunting, underweight, and conflict.

Study Variables

Dependent Variables

Dependent variables in this study are stunting (HAZ < -2), wasting (WHZ <-2) and underweight (WAZ < -2) as measures of undernutrition based on the WHO Child Growth Standards. **S**tunting was calculated as the percentage of children aged 6 to 59 months, whose height for age Z scores (HAZ) is below –2 deviations from the median of the WHO Child Growth Standards. Wasting was calculated as a percentage of children aged 6 to 59 months whose weight for height Z scores (WHZ) is below –2, standard deviations from the median of the WHO Child Growth Standards while underweight will be calculated as the percentage of children aged 6 to 59 months whose weight for age Z scores (WAZ) is below –2 standard deviations from the median of the WHO Child Growth Standards.

Independent Variables

Independent variables in this study are risk factors for undernutrition in children. According to the UNICEF conceptual framework of the determinants of child undernutrition, immediate risk factors for childhood undernutrition are disease and inadequate dietary intake which are influential at the individual child level (UNDP, 2013). In this study, disease was measured by incidence of diarrhea, acute respiratory infection, malaria, and measles while dietary intake was measured by household dietary diversity score (HDDS) as a proxy for individual dietary intake that is not collected in the nutrition survey.

The other risk factors for childhood undernutrition are inadequate access to food, poor child feeding practices, poor hygiene and limited access to health services which are influential at the household level (UNDP, 2013). In this study, access to food was measured by household dietary diversity score while child feeding practices was measured by breastfeeding practices (child aged 6-24 months breastfeeding [Yes/No], exclusive breastfeeding [Yes/No], duration of breastfeeding [months] and complementary feeding [frequency of feeding]). Hygiene in this study was be measured by access to safe water [Yes/No] and access to a latrine[Yes/No] while access to health services was be measured by access to a health facility [Yes/No]. This study also considered gender of the household head and age of the mother as additional factors that could affect child feeding practices and child nutrition at the household level.

Beyond the factors that increase the risk of child undernutrition at individual child and household level, there are society level factors such as livelihood system, area of residence, social economic environment, gender perceptions, displacement and conflict that influence access and quality of resources necessary for supporting good child nutrition in the household. In this study variables at the society level of influence were measured by the type of livelihood system, geographical region, and conflict. Four types of livelihood systems, namely: Pastoralists, Agro pastoralists, Riverine, IDP, and Urban were considered in this study. Armed conflict was measured by the count of incidences of armed conflict in the area of the study. Data on armed conflict was retrieved from the Armed Conflict Location and Event Data Project (ACLED).

Confounding Factors

There are several factors that are not included in UNICEF's conceptual framework of determinants of undernutrition that could influence child undernutrition or modify the effect of known risk factors. Such factors were considered as covariates or confounding variables in this study. Age of the child, gender of the child, age of the mother, and gender of the household head were tested as covariates or confounding variables and controlled accordingly. The schematic diagram in Figure 2 summarizes variables in this study

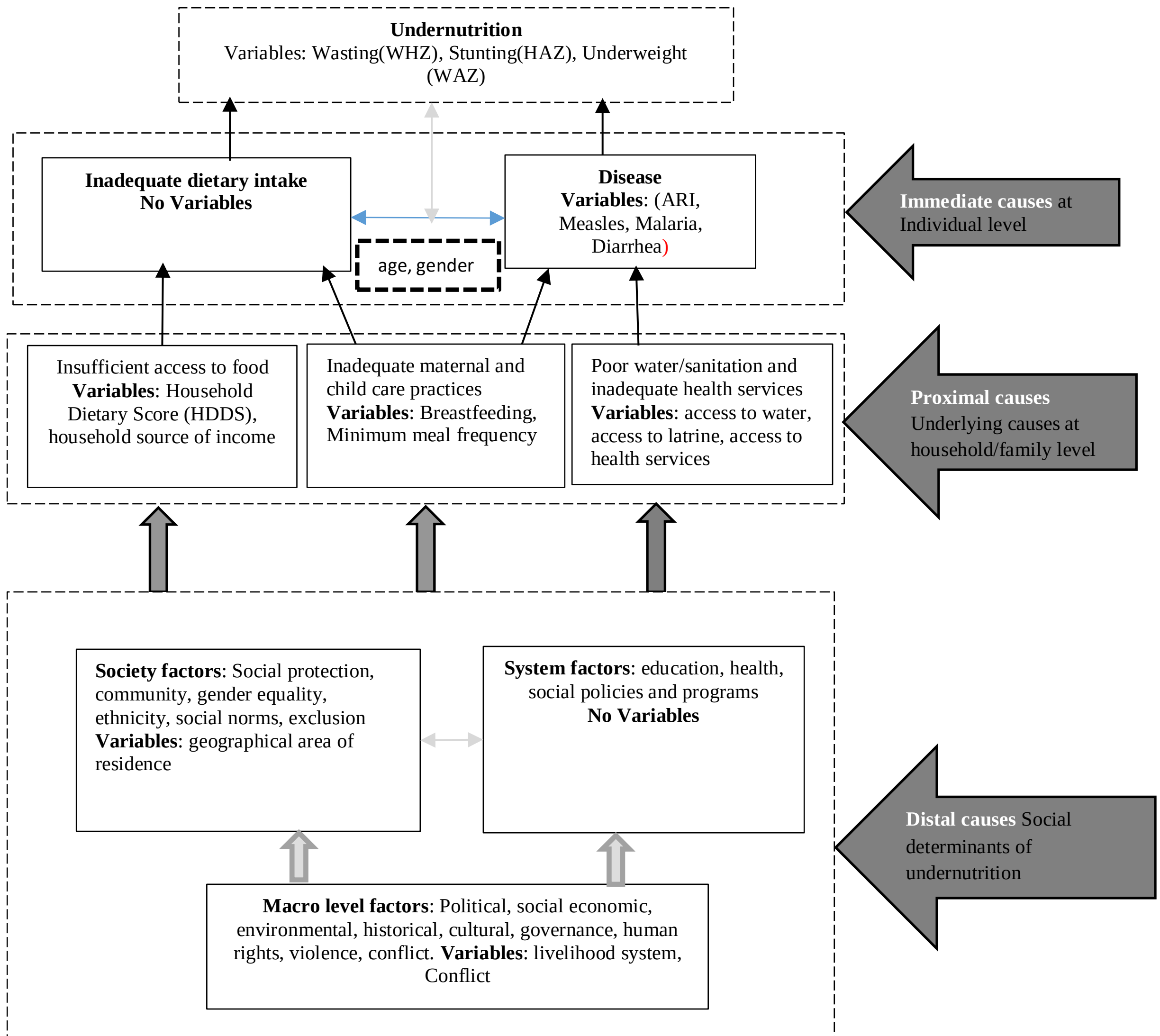

Figure 2. Schematic diagram of study variables.

Adapted from the Strategy for improved nutrition of children and women in developing countries by UNICEF, The Indian Journal of Pediatrics 58 (3) p.22 and Tackling Structural and Social Issues to Reduce Inequities in Children's Outcomes in Low- to Middle-income Countries Office of Research Discussion Paper by Bell, Donkin and Marmot (2013), p.13

Data Analysis Plan

Data analysis in this study included descriptive analysis, trend analysis, bivariate, and multivariate analysis. Table 1 shows a summary of the data analysis plan. Under respective headings, I describe the analysis that I conducted for each research question.

Table 1

Summary of the Data Analysis Plan

Research question	**Measures/variables**	**Sample**	**Data analysis**
RQ1: What are trends in terms of prevalence of underweight, stunting, and wasting in SCS from 2007 to 2012?	Prevalence of stunting, wasting, underweight	75,756 children	Descriptive analysis- Frequencies, plots Trend analysis
RQ2: Does dietary diversity and disease significantly predict underweight, wasting, and stunting in SCS?	Dependent: stunting(Y/N), wasting (Y/N), underweight(Y/N) Independent: dietary diversity (HDDS) and disease (diarrhea, pneumonia, malaria, measles), while the dependent variable is undernutrition measured by wasting (Yes/No), underweight (Yes/No) and stunting (Yes/No) Covariates/cofounders: Age, gender of the child	60,856 children	Bivariate and multivariate analysis using GEE
RQ3: Does dietary diversity, child feeding practices, access to safe water, and access to health care significantly predict underweight, wasting and stunting in SCS?	Dependent: stunting(Y/N), or wasting (Y/N) or underweight(Y/N) Independent: dietary diversity (household diet score) child feeding practices (exclusive breast feeding, Min Meal Frequency), access to	60,856 children	Bivariate and multivariate analysis using GEE

(table continues)

Research question	Measures/variables	Sample	Data analysis
	safe water access to sanitation, access to health care, mothers age, gender of the household head		
RQ4: Does displacement, area of residence, livelihood system and conflict significantly predict underweight, wasting and stunting in SCS?	Dependent: stunting(Y/N), wasting (Y/N), underweight(Y/N) Independent variable:livelihood system, region, Season, and conflict (# of events reported).	60,856 children	Bivariate and multivariate analysis using GEE
RQ5: Are dietary diversity, disease, child feeding practices, access to safe water, access to health care, displacement, area of residence, livelihood system and conflict significant predictors of underweight, wasting and stunting in SCS between 2007 and 2012, when all levels of exposure are considered simultaneously?	Dependent: stunting(Y/N), wasting (Y/N), underweight(Y/N) Independent: dietary diversity, disease, child feeding practices, access to safe water, access to sanitation facilities, access to health care, livelihood system, Region and conflict	60,856 children	Multivariate analysis using GEE
RQ6: How do the predictors of underweight, wasting, and stunting in SCS change between 2007 and 2012?	Prevalence of stunting, wasting, underweight Descriptive analysis of trends	60,856 children	Descriptive analysis-Frequencies, plots

Descriptive Analysis

The first step of data analysis was descriptive analysis to generate descriptive statistics that described the sample and its distribution. Descriptive statistics describe the distribution of the data, central tendency, and dispersion (Trochim, 2006). Since most of the variables in this study were categorical, I used frequencies to describe their distribution. I also used descriptive analysis to study the prevalence of stunting, underweight, and wasting.

Trend Analysis

To answer the question on the trend of the prevalence of underweight, stunting, and wasting in SCS, the prevalence of underweight, stunting, and wasting was plotted against time (year). Linear regression analysis was then conducted to determine the significance of the trends.

GEEs

Survey data that is used in this study is clustered at household level where individual child data was collected from all the children that were 6-59 in all sampled households which makes the data correlated. As such, to establish the relationship between the different independent variables and the dichotomous dependent variables the GEE approach was taken because of its ability to account for correlation between observations. When compared to other methods like mixed linear models that are also used to analyze correlated data, GEE uses weighted combinations of observations in a cluster to generate more efficient regression parameters, more accurate standard errors and confidence intervals (Hanley, Negassa, Edwardes, & Forrester, 2003). Additionally

GEE models estimate changes in the population level means as a result of given covariates while taking into consideration the correlations between observations (Salazar, Ojeda, Dueñas, Fernández, & Failde, 2016). Such is the analysis that is required in this study that seeks to make population level conclusions using data that is correlated at household level. However, the underside of the GEE approach is that it is not yet developed to analyze multilevel data where clustering is hierarchical (Hanley et al., 2003). This was a limitation for this study because hierarchical modelling of the predictors of undernutrition to determine the change in the risk of undernutrition with progressive exposure to child, household and society level influences could not be done. Microsoft Excel was used to plot trends and other descriptive analysis while statistical analyses were performed using Stata version 13.1 (Stata Corp, College Station, TX).

Research Questions

RQ1: What are trends in terms of prevalence of underweight, stunting, and wasting in SCS from 2007 to 2012?

RQ1 was answered using a descriptive analysis where the prevalence of underweight (Yes/No), wasting (Yes/No), and stunting (Yes/No) was generated using frequencies and plotted against time to determine trends in the prevalence of underweight, wasting and stunting. Linear regression analysis was then conducted to generate the coefficient of determination, R^2 that demonstrated the strength of relationship between time (year) and undernutrition conditions. Linear regression analysis also generated p – values that confirmed significance of the trend at $p<0.05$.

RQ2: Is disease (diarrhea, acute respiratory infections, measles, and malaria) associated with underweight, stunting, or wasting in SCS?

H_0: Underweight, stunting and wasting are not associated with disease **(**Measles infection ($H_0$1), Diarrhea ($H_0$2), Malaria $H_0$3), and Acute Respiratory Infections residence ($H_0$4)

H_a: Underweight, stunting and wasting associated with disease **(**Measles infection (H_a1), Diarrhea (H_a2), Malaria H_a3), and Acute Respiratory Infections residence (H_a4).

RQ3: Are dietary diversity, child feeding [exclusive breastfeeding and feeding frequency], access to safe water, and access to health care associated with underweight, stunting, or wasting in SCS?

H_0: Underweight, stunting and wasting are not associated with dietary diversity ($H_0$5), child feeding practices [exclusive breastfeeding ($H_0$6) and feeding frequency ($H_0$7)], access to safe water ($H_0$8) and access to health care disease ($H_0$9).

H_a: Underweight, stunting and wasting are associated with dietary diversity (H_a5), child feeding practices [exclusive breastfeeding (H_a6) and minimum meal frequency (H_a7)], access to safe water (H_a8) and access to health care disease (H_a9).

RQ4: Is the area of residence, livelihood system, and armed conflict associated with underweight, stunting, or wasting in SCS?

H_0: Underweight, stunting and wasting vary by area of residence ($H_0$10), Livelihood system ($H_0$11) and conflict ($H_0$12)

H_a: Underweight, stunting and wasting do not vary by area of residence (H_a10), Livelihood system (H_a11) and armed conflict (H_a12)

To answer RQ2, 3 and 4, a bivariate analysis using GEE was first conducted to determine factors that had a relationship with underweight, wasting, and stunting. Factors that were significant in the bivariate analysis were then used in a multivariate analysis to determine the factors that were statistically significant at child level, household level and society level for questions 2, 3 and 4 respectively.

In RQ2, the independent variables were disease measured by reported diarrhea (Yes/No), malaria (Yes/No), ARI (Yes/No) and measles (Yes/No), while the dependent variables were wasting (Yes/No), underweight (Yes/No) and stunting (Yes/No). In research question three, the independent variables were dietary diversity measured by the HDDS, child feeding practices (exclusive breastfeeding, minimum meal frequency), access to safe water, access to sanitation facility, access to health care, mothers age and gender of the household head while the dependent variable is undernutrition measured by wasting (Yes/No), underweight (Yes/No) and stunting (Yes/No). In the research question five, the independent variables were area of residence (region), livelihood system and conflict while the dependent variable is undernutrition measured by wasting (Yes/No), underweight (Yes/No) and stunting (Yes/No).

This analysis generated odds ratios for underweight, stunting, and wasting. Overall significance of the models was assessed using Prob > chi2 where the model was considered statistically significant at $p < 0.05$. Crude Odds Ratios and Adjusted Odds Ratios were used to determine the association of each variable with the outcome if it was significant at $p<0.05$.

RQ5: Are dietary diversity, disease, child feeding practices, access to safe water, access to health care, displacement, area of residence, livelihood system, and conflict significant predictors of underweight, stunting, and wasting in SCS between 2007 and 2012, when all levels of exposure are considered simultaneously?

H_0: Dietary diversity, disease, child feeding practices, access to safe water, access to health care, displacement, area of residence, livelihood system, and conflict do not have a relationship with underweight, stunting, and wasting when all levels of exposure are considered simultaneously.

H_a: Dietary diversity, disease, child feeding practices, access to safe water, access to health care, displacement, area of residence, livelihood system, and conflict have a relationship with underweight, stunting, and wasting when all levels of exposure are considered simultaneously.

RQ5 was answered through multivariate analysis using GEE. A model was constructed using factors that were found to be statistically significant at each of the conceptualized levels of causes of undernutrition; child, household, and society level. Significance of the model was determined by using the chi-square test statistic where Prob > chi2 was significant at $p < 0.05$ while odds ratios were used to determine the association between independent variables and the outcome if significant at $p<0.05$.

RQ6: How do predictors of underweight, stunting, and wasting in SCS change between 2007 and 2012?

RQ6 was answered using a descriptive analysis where the prevalence of significant predictors of underweight, wasting and stunting was generated using frequencies and plotted against time to determine trends in the prevalence of underweight, wasting and stunting. Linear regression analysis was then conducted to generate the coefficient of determination, R^2 that demonstrated the strength of relationship between time (year) and predictor variables. Linear regression analysis also generated p-values that confirmed significance of the trend at $p<0.05$.

Power and Sample Size

According to Sullivan (2012), a good hypothesis has a low probability of committing type I =error shown by a small value of alpha (α) and a low probability of committing type II error shown by a high power (1-β). In this study, a conventional value of α at 0.05 will be used. Statistical power is the probability that a given test will correctly reject the null hypothesis (Lisa.M Sullivan, 2012). Statistical power for each hypothesis will be calculated and reported. Statistical power (1-β) is dependent on the level of significance (α), sample size, and effect size (f^2). A medium effect size will be expected for all the research questions. This study has a total sample of 87,731children participated in 12 surveys from 2007-2012, of these 75,756 observations were used for the analysis on trends while 60,856 observations were used in the analysis on predictors of undernutrition. Two different sample sizes were used according to the completeness of data that was required for the respective analysis.

Threats to Internal and External Validity

Internal validity is assured when the variables are a true measure of what is intended to be studied, and any association between dependent and independent variables are free of bias. In this study, internal validity will also be threatened by some changes in the questions where some questions though seeking the same information were asked differently between studies. This limitation was overcome by recording new variables that harmonized responses from similar questions into common response options.

External validity is the extent to which findings of a study can be generalized to a population beyond the study population. This study used data collected from studies that used a valid sampling methodology for population level surveys as prescribed by the SMART methodology (SMART, 2017) which makes the results generalizable at population level. Further, the nutrition survey guidelines that were followed in the primary data collection indicate that probability sampling was followed while large samples were used to mitigate any possible cluster sampling bias. While standard sampling methodology was used in the survey design, actual implementation of the surveys could have been affected by insecurity where data collection could have been eventually limited to accessible communities. However, the multiplicity of surveys conducted over the 6 years generates allowed all geographical regions to be surveyed at some point generating finds that are generalizable.

Ethical Procedures

In line with the ethical requirement of Walden University, an IRB approval was received prior to commencing any data processing procedures. FSNAU provided a letter approving the use of all the data that was be used in this study. The Ministry of Health in Somalia also provided a letter supporting this study and agreeing to the publication of the research outcomes.

Protection of Human Participants

This study did not pose any risks to human participants because I used secondary anonymized data provided by FSNAU. FSANU also collected anonymized in the primary surveys. As such, participants in the nutrition surveys that generated the data that I used in this study are not traceable.

Summary

In this chapter, I described the methodology used for this study. A quantitative cross-sectional design was used to examine trends of prevalence and predictors of undernutrition among children aged 6-59 months in SCS. Data from nutrition surveys conducted by FSNAU from 2007 to 2012 was merged into a single dataset and analyzed using Stata version 13.1 and Microsoft Excel. Linear regression was used to examine trends in prevalence of undernutrition and trends of significant predators while GEE was used to determine predictors of undernutrition in SCS. The results are presented in Chapter 4 and discussed with conclusions and implications for the study presented in Chapter 5.

Chapter 4: Results

Introduction

The purpose of this study was to examine trends in terms of prevalence and predictors of undernutrition that present in the form of underweight, stunting, and wasting. I assessed trends in the prevalence of underweight, stunting, and wasting from 2007-2012 by age and livelihood system. I investigated predictors of underweight, stunting, and wasting at individual child, household, and society level. I also assessed the predictors of underweight, stunting, and wasting when all the exposure levels are considered simultaneously and as well as the trends in identified significant predictors. In this chapter, I present the results of the study for each research question.

Research Questions

This study sought to answer the following questions:

RQ1: What are trends in terms of prevalence of underweight, stunting, and wasting in SCS from 2007 to 2012?

RQ2: Is disease (diarrhea, acute respiratory infections, measles, and malaria) associated with underweight, stunting, or wasting in SCS?

RQ3: Are dietary diversity, child feeding (exclusive breastfeeding and feeding frequency), access to safe water, and access to health care associated with underweight, stunting, or wasting in SCS?

RQ4: Is the area of residence, livelihood system, and conflict associated with underweight, stunting, or wasting in SCS?

RQ5: Are dietary diversity, disease, child feeding practices, access to safe water, access to health care, displacement, area of residence, livelihood system, and conflict significant predictors of underweight, stunting, and wasting in SCS between 2007 and 2012, when all levels of exposure are considered simultaneously?

RQ6: How do predictors of underweight, stunting, and wasting in SCS change between 2007 and 2012?

Study Findings

Description of the Sample

A total of 87,731 children aged 6-59 months participated in 12 surveys from 2007 to 2012. Of the children who participated in the 12 surveys, 3,612 children did not have complete anthropometric data, while HAZ, WAZ or, WHZ values for 8,363 children were ±3 Z-scores from the mean of the surveyed population and therefore considered statistically implausible according to SMART survey guidelines. All observations with missing anthropometric data or with implausible values were eliminated from the analysis regarding the prevalence of undernutrition, leaving a total sample of 75,756 that was used in the trend analysis. However, to cater for household level randomized effects in the analysis of predictors of undernutrition, an additional 14,900 children from households that did not have household numbers to uniquely identify them were excluded. As such, the analysis of predictors of undernutrition used a sample of 60,856. A summary of the study sample is depicted in Figure 3.

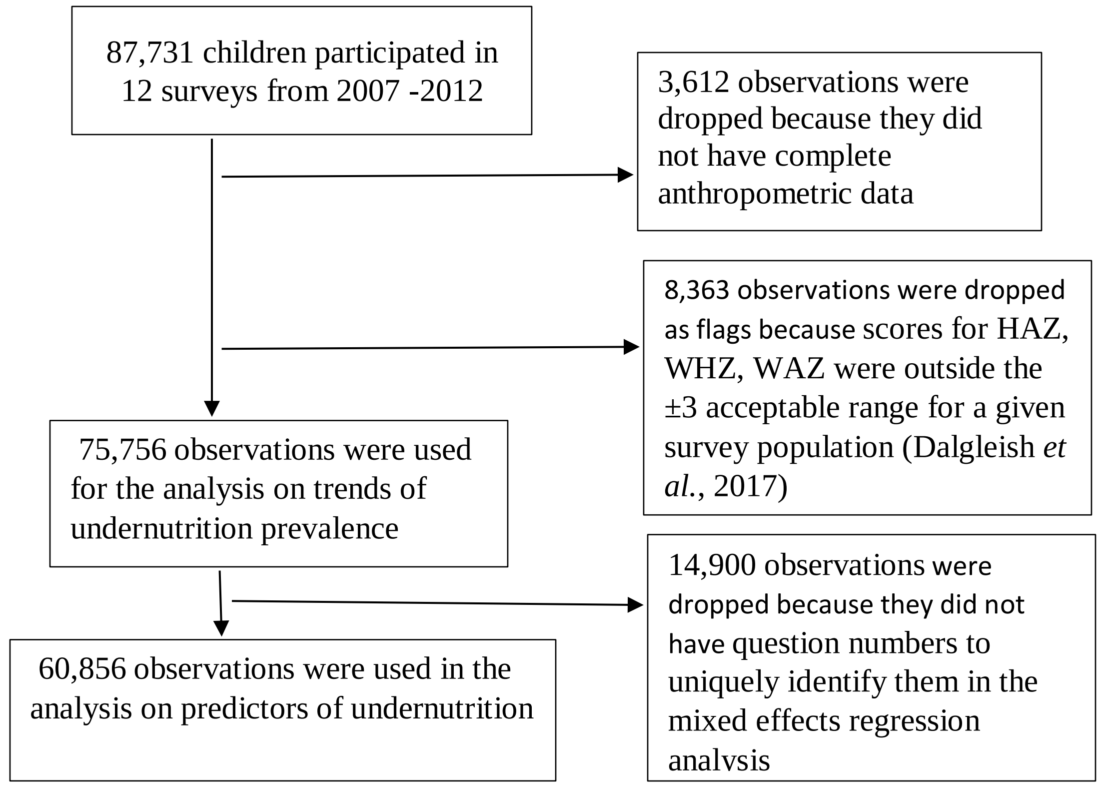

Figure 3. Summary of sample data

The study sample had complete data on all outcome variables, but had missing data on nearly 80% of the predictor variables. Chi-square tests were conducted to compare the difference between samples with complete data and samples with missing data for variables that were missing more than 10% of the values. The chi-square analysis revealed that the differences were not statistically significant for most of the variables, but for all variables, available data was large enough to detect the effect of the predictors. However, findings should be examined with this limitation in mind.

The majority (27.7%) of the children covered in this study participated in 2007 while 2010 had the lowest proportion (6.5%) of children surveyed. Variations in annual and regional sample sizes could be linked to prevailing security conditions that would affect the ability to access populations to conduct the surveys. The likely effect of security survey implementation and therefore sample sizes can be collaborated by data from the Armed Conflict Location & Event Data Project (ACLED), that shows that Banadir had the highest reported security incidences over the study period compared to Gedo, which had the lowest reported number of security incidences. Across the study period, Gedo and Hiran regions had the highest proportion of children covered while Bakool and Banadir regions had the lowest proportions of children covered (see Table 2).

Table 2

Sample Distribution by Nutrition Status, Age, Sex, Season, Livelihood System, and Region (N = 75,756)

Variable	2007		2008		2009		2010		2011		2012		**Total**	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Nutrition														
Normal[1]	7081	34.1	4275	29.3	5448	32	2206	47.8	2833	33.3	4989	47.6	26769	35.3
Underweight	4655	22.7	3561	24.4	4126	24.2	806	17.4	2114	24.9	1840	17.6	17102	22.6
Stunting	5828	28.4	4369	30	4539	26.6	778	16.8	1643	19.3	1945	18.6	19102	25.2
Wasting	3040	14.8	2378	16.3	2931	17.2	833	18	1908	22.5	1693	16.2	12783	16.9
Age														
=<24	6827	33.2	5250	36	6279	36.8	1653	35.8	3775	44.4	4146	39.6	27930	36.9
>24	13714	66.8	9333	64	10765	63.2	2970	64.2	4723	55.6	6321	60.4	47826	63.1
Sex														
Male	10423	50.7	7415	50.8	8550	50.2	2378	51.4	4123	48.5	5158	49.3	38047	50.2
Female	10118	49.3	7168	49.2	8494	49.8	2245	48.6	4375	51.5	5309	50.7	37709	49.8
Season														
GU	10423	50.7	7415	50.8	8550	50.2	2378	51.4	4123	48.5	5158	49.3	38047	50.2
DEYR	10118	49.3	7168	49.2	8494	49.8	2245	48.6	4375	51.5	5309	50.7	37709	49.8
Livelihood system														
Pastoral	3924	20.7	4092	29.1	4715	28.6	1951	42.2	3588	44.8	1485	14.2	19755	27.2
Agricultural	8868	46.9	4319	30.7	7671	46.5	685	14.8	1327	16.6	1497	14.3	24367	33.6
Riverine	6132	32.4	3834	27.3	3259	19.8	586	12.7	510	6.4	1257	12	15578	21.5
Urban	-	-	-	-	-	-	87	1.9	928	11.6	1710	16.3	2725	3.8
IDP	-	-	1816	12.9	855	5.2	1314	28.4	1663	20.7	4518	43.2	10166	14
Region														
Bakool	1859	9.7	722	5.3	849	5.5	-	-	115	1.4	608	5.8	4153	5.8
Hiran	4808	25.0	1423	10.5	3031	19.5	-	-	116	1.4	-	-	9378	13.1
Galgaduud	544	2.8	700	5.2	1710	11.0	1160	25.7	1409	16.6	586	5.6	6109	8.5
M.Shabelle	1012	5.3	982	7.2	2527	16.2	687	15.2	-	-	-	-	5208	7.2
L.Juba	1409	7.3	1802	13.3	1246	8.0	-	-	1833	21.6	245	2.3	6535	9.1
M.Juba	2016	10.5	1724	12.7	1092	7.0	-	-	1702	20.0	-	-	6534	9.1
L.Shabelle	1798	9.3	1965	14.5	1688	10.9	1355	30.0	78	0.9	955	9.1	7839	10.9
Gedo	1952	10.1	3755	27.7	3411	21.9	1277	28.3	980	11.5	4076	38.9	15451	21.5
Bay	3843	20.0	113	0.8	-	-	40	0.9	394	4.6	1227	11.7	5617	7.8
Banadir	-	-	379	2.8	-	-	-	-	1871	22.0	2770	26.5	5020	7.0

Age and Sex Distribution

Children that participated in this study are aged between 6 and 59 months. The mean age is 31.6 months while the most common age is 48 months. Sixty-three percent of the children were above the age of 24 months while 37% were 24 months old or younger. Overall the age range is evenly distributed across the sample. Gender in this sample was equally distributed with 50% [50.2] male and 50% [49.8] female children.

Livelihood distribution

This study focuses on five broad livelihood systems that are found in Somalia: Pastoral, Agropastoral, Riverine, Internally Displaced Persons (IDP) and Urban. The majority (33.6%) of children that participated in this study live in agro-pastoral areas. Twenty-s percent of the participants live in pastoral areas, 22% live in riverine areas, and 14% are internally displaced persons who live in camps, while 4% live in urban areas.

Prevalence of Underweight, Stunting, and Wasting

Underweight

On average, 22.6% of the children in this study were underweight with the highest level of underweight observed in 2011 (24.9%). The prevalence of underweight was higher among children younger than 24 months and male children. Within seasons, underweight was most prevalent in the Gu Season compared to the Deyr Season while within livelihood systems, underweight was highest among agropastoralists. Within individual regions, Bay had the highest (27%) level of underweight children while Banadir had the lowest (16.0%) level (see Table 3).

Stunting

Twenty-five percent of the children that participated in surveys throughout this study were stunted with the highest proportion observed in 2008 (30%) and the lowest observed in 2010 (16.8%). Stunting was most prevalent among children aged above 24 months (25.4%) than among children under the age of 24 months (24.9%) and observed more among male children (27.8%) than female children (22.6%). Of the two seasons, stunting was most observed in Gu (27%) compared to Deyr season (23.1%) and within livelihood systems, stunting was highest among riverine (31%) populations and lowest among urban (8.4%) populations. Within regions, Middle Juba had the highest (33.5%) prevalence of stunting while Banadir had the lowest (10.8%) prevalence of stunting (see. Table 3)

Wasting

Compared to the other forms of undernutrition, wasting had the lowest average prevalence of 16.9% where the highest level of prevalence was observed in 2011 at 22.5%. Wasting was observed more among children above the age of 24 months (17.0%) than it was younger children (16.6%). However, similar to underweight and stunting, wasting was more prevalent among male children (18.9%) than it was among female (14.8%) children and more prevalent in Gu than Deyr season. Within livelihood systems, wasting was more prevalent among pastoral populations (18.6%) and lowest among urban populations (14.8%). Comparing the regions, wasting was most prevalent in Gedo (20.6%) and least prevalent in Lower Shabelle (13.5%) (see Table 3)

Table 3

Prevalence of Underweight, Stunting, and Wasting (N = 75,756)

Variable	**Underweight**		**Stunting**		**Wasting**	
	N	%	N	%	N	%
Age						
=<24	6498	23.3	6956	24.9	4643	16.6
>24	10604	22.2	12146	25.4	8140	17.0

Variable	Underweight		Stunting		Wasting	
	N	%	N	%	N	%
Sex						
Male	9529	25.0	10590	27.8	7197	18.9
Female	7573	20.1	8512	22.6	5586	14.8
Season						
Deyr	7631	21.6	8192	23.1	5837	16.5
Gu	9471	23.5	10910	27.0	6946	17.2
Livelihood system						
Pastoral	4096	20.7	3943	20.0	3683	18.6
Agricultural	6126	25.1	7054	28.9	4087	16.8
Riverine	3680	23.6	4831	31.0	2353	15.1
Urban	347	12.7	229	8.4	402	14.8
IDP	2103	20.7	2199	21.6	1681	16.5
Region						
Bakool	957	23.0	1020	24.6	699	16.8
Hiran	2113	22.5	2204	23.5	1558	16.6
Galgaduud	1222	20.0	1232	20.2	951	15.6
M.Shabelle	1183	22.7	1365	26.2	900	17.3
L.Juba	1388	21.2	1730	26.5	1067	16.3
M.Juba	1714	26.2	2188	33.5	1099	16.8
L.Shabelle	1566	20.0	2153	27.5	1058	13.5
Gedo	3811	24.7	3681	23.8	3179	20.6
Bay	1519	27.0	1805	32.1	977	17.4
Banadir	803	16.0	544	10.8	841	16.8

Note. Children that are not underweight, stunted, or underweight are not listed.

Analysis of Trends in Prevalence of Underweight, Stunting, and Wasting

A descriptive analysis of trends in underweight, stunting, and wasting was conducted using a total sample of 75,756 children that participated in nutrition surveys from 2007 to 2012. Results of the analysis are presented in the sections that follow. In addition, the prevalence of underweight, stunting, and wasting is plotted against time to show their trend.

Overall Trend of Underweight, Stunting, and Wasting

A plot of underweight by year showed that the prevalence of underweight increased between 2007 and 2008. In 2009 the trend started to decline with a sharp decline in 2010 before rising again in 2011 (Figure 4). A linear regression of underweight against time revealed a decreasing trend ($R^2 = 0.23$), but the trend was not statistically significant ($p = 0.339$).

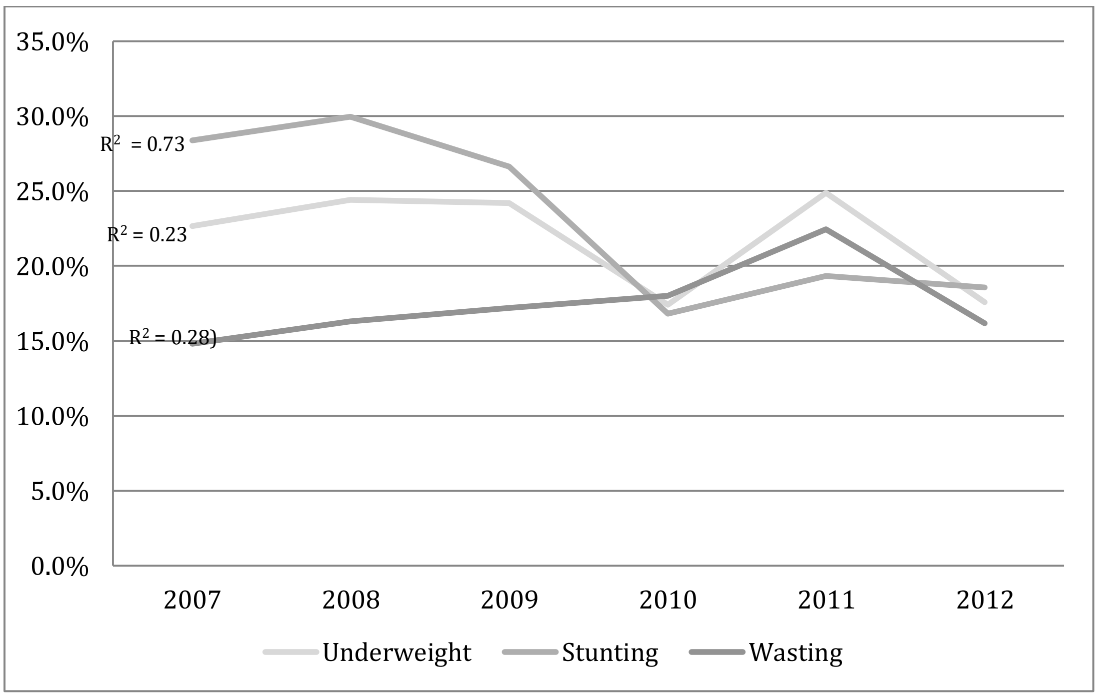

Figure 4. Trend in underweight, stunting and wasting

A plot of stunting by year showed a pattern similar to underweight (see Figure 4). Between 2007 and 2008, stunting increased but started to decline in 2009 with a sharp deep in 2010 before rising again in 2011 and declining slightly in 2012. Linear regression of stunting and time showed a declining trend (R^2 = 0.73) that was statistically significant ($p < 0.05$). A plot of wasting by year showed a continually increasing prevalence of wasting from 2007, peaking in 2011 before declining in 2012 (Figure 4). While the prevalence of wasting was lower than the prevalence of both underweight and stunting over most of the study period, it was persistently above WHO 15% emergency threshold. A linear regression of the prevalence of wasting against time showed that wasting was increasing (R^2 = 0.28), but the trend was not statistically significant (p = 0.285).

Trend of Underweight, Stunting, and Wasting by age

A plot of underweight by age by year showed a slight increase in the prevalence of underweight among all the children remaining stable until in 2009 when there was a sharp decline especially among children aged 24 months or less (Figure 5). In both age groups, a rapid increase in underweight was observed in 2011, followed by a decline in 2012. However, there was no observable underweight trend among children aged 24 or younger, but a declining trend was observed for children above the age of 24 though it was not statistically significant (R^2 = 0.61; p=0.066).

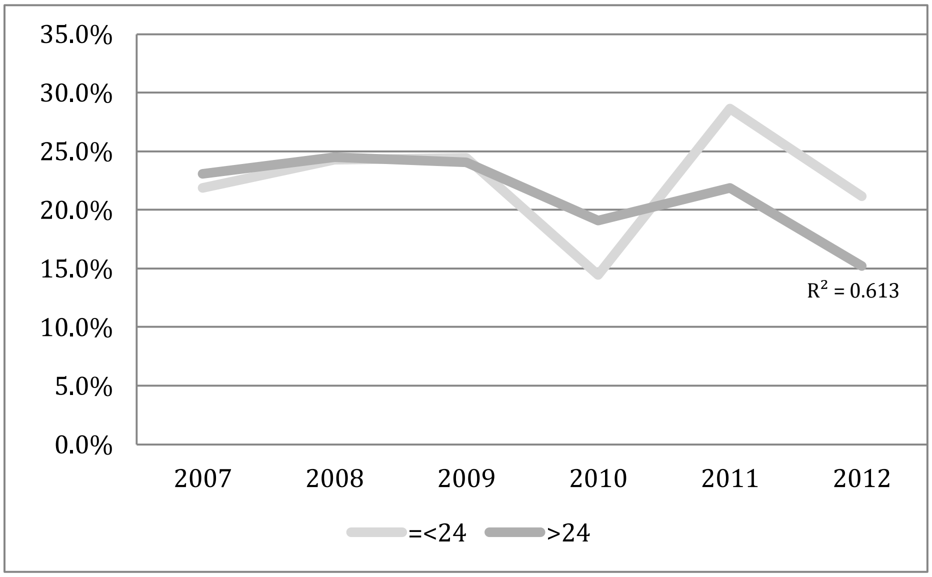

Figure 5. Underweight trend by age group

The plotted trend of stunting shows a slight increase between 2007 and 2008 and after that a steady decline until 2010 among both the 24 months or younger and those above 24 months old (Figure 6). From 2010 until 2012, the prevalence of stunting stabilizes among children above 24 months old but increases among those that are 24 months or younger; only showing a slight decline in 2012. While a declining trend in stunting was observed among both age groups, the decline among those above 24 months old was stronger and statistically significant when compared to the trend among 24 months or younger (R^2 = 0.81; $p<0.05$ vs. R^2 = 0.47; p=0.133). Among children that are older than 24 months, prevalence of wasting increased gradually from 2007 until 2009 when it takes a sharp increase until 2011 and then slightly declines in 2012. While the overall trend of wasting among children above 24 months was increasing, it was not statistically significant (R^2 = 0.27; p=0.288).

Figure 6. Stunting trend by age group

Among children that are 24 months or younger, the prevalence of wasting increased slightly between 2007 and 2009. The trend declined in 2010 and then increased sharply increase in 2011, as shown in Figure 7. Overall, the trend of wasting among children aged 24 months or younger was increasing but, was not statistically significant (R^2 = 0.97; p=0.548).

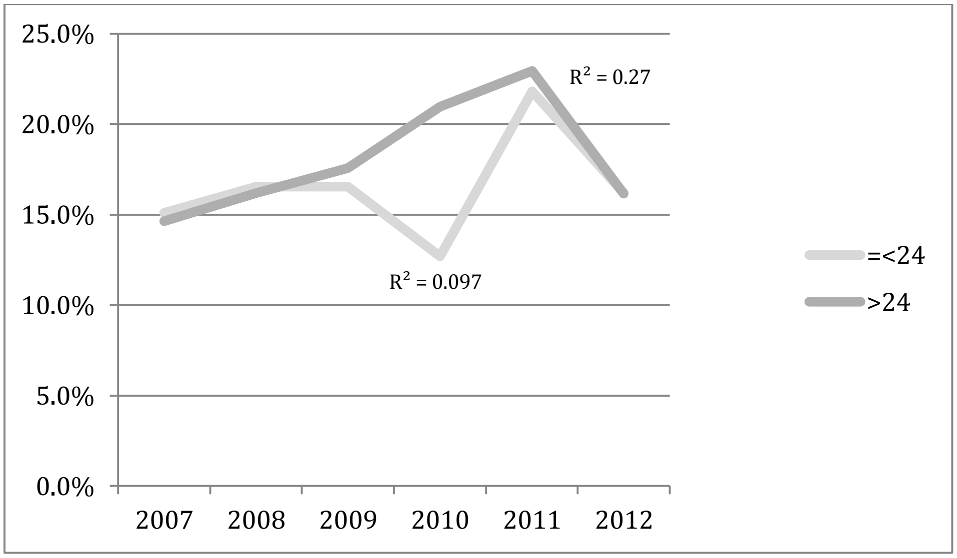

Figure 7. Wasting trend by age group.

Trend of Underweight, Stunting, and Wasting by livelihood

A plot of underweight by livelihood showed stability in the prevalence of underweight among all the four livelihood groups between 2007 and 2009 (see Figure 8). Later among the agropastoralists and IDP populations, the prevalence of underweight drops sharply in 2010 but rises again in 2011 and then drops in 2012. Among the riverine population, underweight steadily increases from 2009 until 2011 to the highest level of all the livelihood groups before dropping in 2012 to a level only higher than the urban populations. The underweight trend is less fluctuating among pastoral populations where it shows a slight increase between 2007 and 2009 and then decreased gradually until 2012. Underweight is generally lower among urban populations showing a slight increase from 2010 to 2011 and then a decline in 2012. Of all the livelihoods, only the trend among pastoral and urban livelihoods was observable, but even then they were weak trends and statistically insignificant (R^2 = 0.10; p=0.793; R^2 = 0.25; p=0.317 respectively).

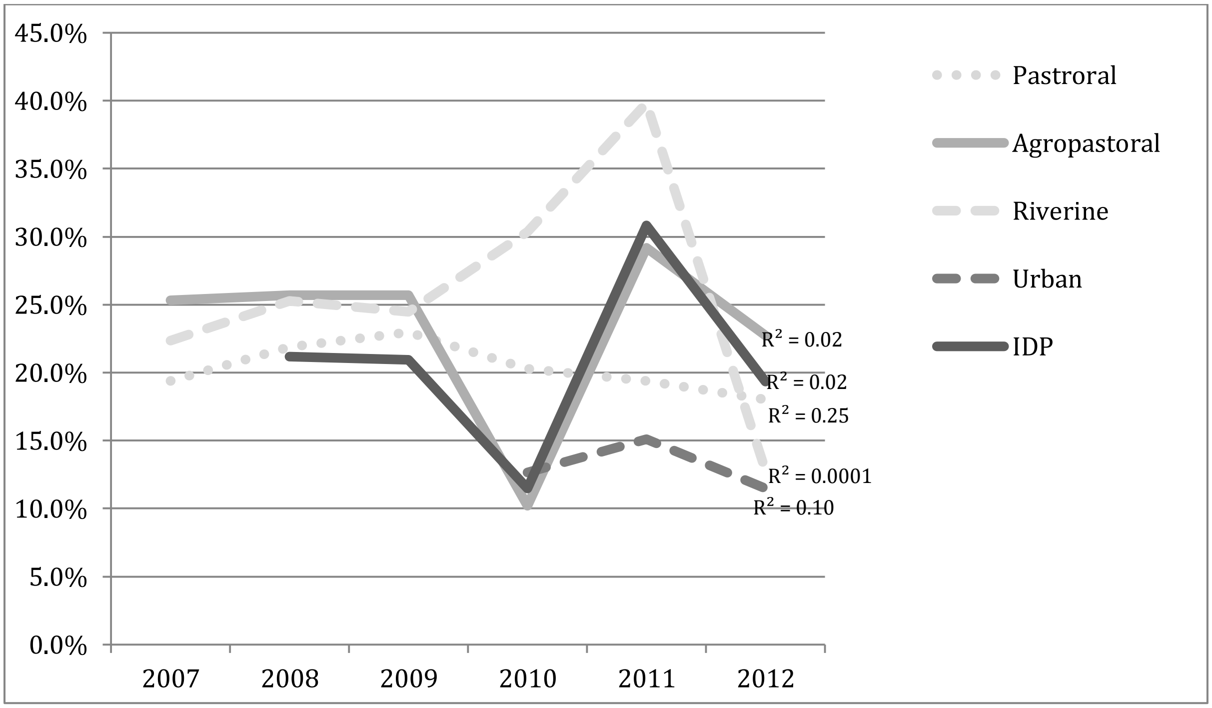

Figure 8. Underweight trend by livelihood.

The prevalence of stunting showed a slight but steady decline among pastoral populations from 2007 to 2012 (R^2 = 0.92; p <0.01) (Figure. 9). Among agropastoralists, stunting showed a slight decline between 2007 and 2009 and then a sharp decline in 2010 before a rapid increase until 2012 where it is highest of all the livelihoods. However overall, there was no observable trend (R^2 = 0.037; p = 0.715). From 2007 to 2008, stunting showed an increase in the riverine population, then steadily declined until 2010 and then increased in 2011 but significantly dropped in 2012. Overall, the trend of stunting in the riverine population was declining, but it was not statistically significant (R^2 = 0.513; p =0.109). Among the IDP population, stunting declined from 2008 until

2010 and then increased in 2011 but remained slightly stable in 2012; overall the trend was declining, but it was not statistically significant (R^2 = 0.408; p =0.246). Stunting among the urban population showed a steady decline from 2010 until 2012 (R^2 = 0.997; p <0.05). The stunting trend was stronger among pastoral (R^2 = 0.92; p<0.01) and urban populations (R^2 = 0.997; p<0.05).

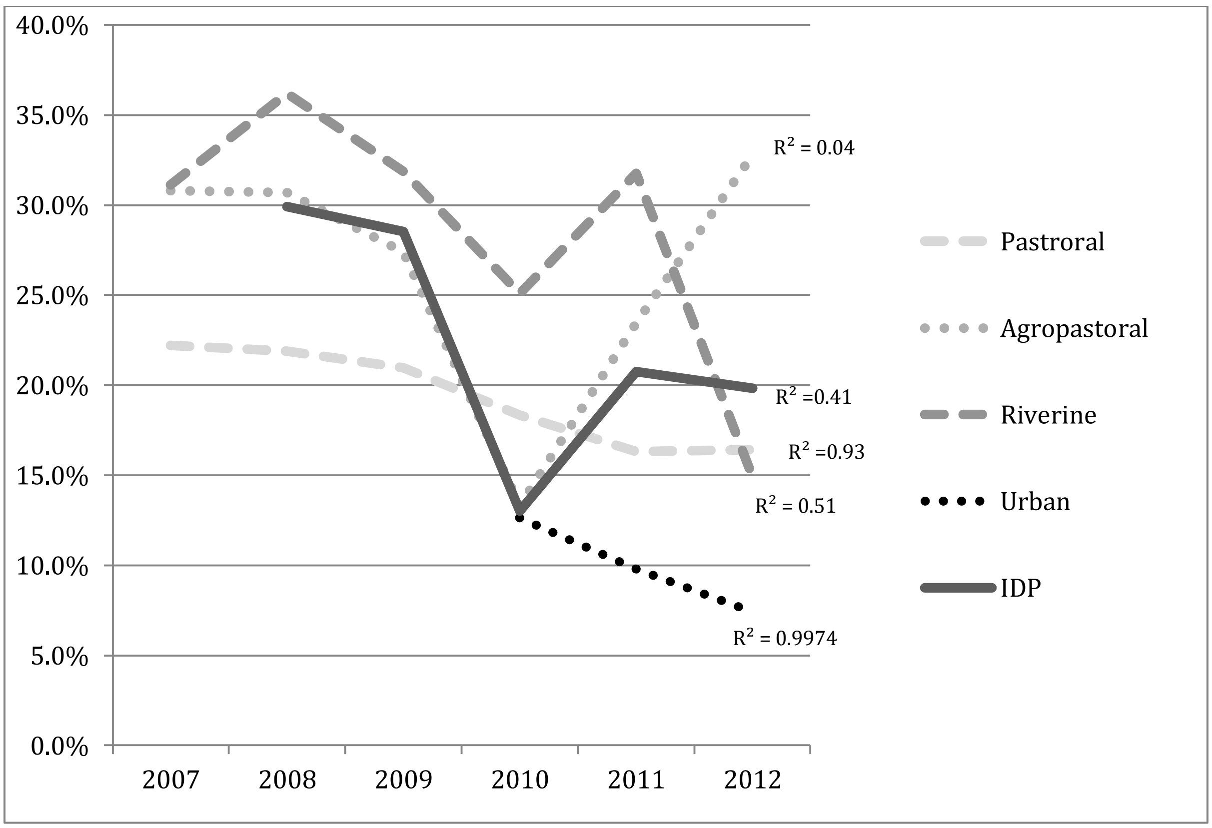

Figure 9. Stunting trend by livelihood.

As shown in Figure 10, the prevalence of wasting among the pastoral population, steadily increased trend from 2007 to 2012 with only a slight decline in 2010; however, the trend was not statistically significant (R^2 = 0.58; p=0.079). In 2012, wasting was highest among the pastoralist population. Among agropastoralists, wasting showed a more fluctuating trend where it increased from 2007 to 2009 then dropped in 2010, increased in 2011, and then dropped again in 2012 (Figure 10). Overall, there was no observable trend of wasting among agropastoralists (R^2 = 0.05; p=0.668). Among the riverine population, the prevalence of wasting was stable and below the 15% emergency threshold from 2007 until 2009 when it rapidly increased until 2011 to the highest level of all the livelihoods and then dropped in 2012. This trend was, however, not statistically significant (R^2 = 0.35; p=0.220). Prevalence of wasting among the IDP population increased from 2008 until 2011 when it peaked and then dropped in 2012. While showing an increasing trend in all population groups except urban populations, the trend was not statistically significant in any livelihood population.

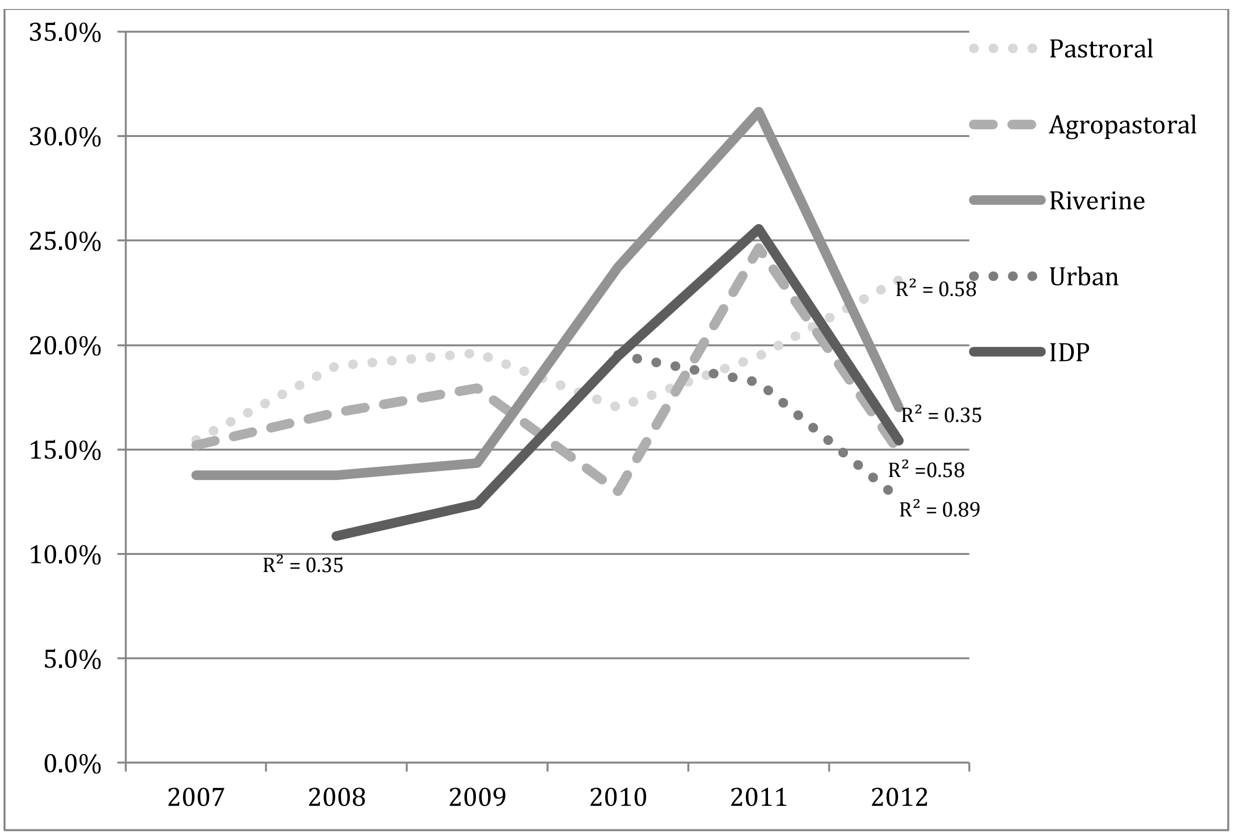

Figure 10. Wasting trend by livelihood.

Analysis of Predictors of Underweight, Stunting, and Wasting

Child Level Predictors of Undernutrition

RQ2: Is disease (diarrhea, ARI, measles, and malaria) associated with underweight, stunting, or wasting in SCS?

H_0: Underweight, stunting and wasting are not associated with disease namely Diarrhea ($H_0$1), Malaria ($H_0$2), ARI ($H_0$3), and Measles infection ($H_0$4).

H_a: Underweight, stunting and wasting are associated with disease Diarrhea ($H_0$1), Malaria ($H_0$2), ARI ($H_0$3), and Measles infection ($H_0$4).

This question sought to establish immediate predictors of undernutrition, which are the individual child factors that influence undernutrition. I assessed the effect of diarrhea, malaria, ARI, and measles infection as common childhood infections. I also assessed age (=<24 months or >24 months old) and the child's gender as individual child characteristics that might influence the condition of undernutrition.

Over the study period, the average prevalence of measles infection, diarrhea, malaria or fever, and ARI was 3.5%, 18.5%, 20.1% and 20.9% respectively indicating a higher incidence of ARI compared to the other illnesses. Of the children that had a measles infection 22.9% were underweight, 26.8% were stunted while 17.2% were wasted. Twenty-six percent of the children that had malaria were underweight, 30.2% were stunted while 17.6 % were wasted. Among children that had diarrhea, 28% were underweight, 30.3% were stunted, while 19.7% were wasted. Of the children that had ARI, 25.1% underweight, 27.9% were stunted, while 18 % were wasted. Bivariate logistic regression was run for all the illnesses to establish their relationship with each of the outcomes, after which significant predictors were included in a multivariate analysis while controlling for age, sex and year of the study. Results of the analysis are shown in table 4.

Underweight

Of the four child illnesses, diarrhea was found to be the strongest predictor of underweight with an unadjusted odds ratio of 1.41 [95% CI: 1.34, 1.48] at $p < 0.001$. This indicates that the odds of being underweight for a child that has had diarrhea were 41% higher than the odds of a child that has not had diarrhea. ARI and malaria were also found to be significant predictors of underweight where ARI was a stronger predictor. ARI increased the odds of being underweight by 17% compared to Malaria that increased the odds of being underweight by 16% (COR = 1.17, CI [1.12, 1.23], $p<0.001$ and COR = 1.16, 95% CI [1.10, 1.22]; $p<0.001$; respectively). Measles infection was not a significant predictor of underweight (COR = 1.01; 95% CI [0.91, 1.12]; $p = 0.859$).

Bivariate analysis of age group and underweight showed the odds of underweight among children above the age of 24 months are not statistically different from children aged 24 months or younger (COR = 1.03, 95% CI [0.99, 1.07]; $p = 0.164$). Sex, on the other hand, is significantly associated with underweight where the odds of female children being underweight are reduced by 23% when compared to male children (COR = 0.77, CI [0.74, 0.80]; $p <0.001$). Bivariate analysis of calendar year of the study and underweight showed it was significantly associated with underweight where the odds of being underweight were reduced by 5% (COR = 0.95, 95% CI [0.93, 0.96]; $p <0.001$) with every additional year.

Multivariate logistic regression of diarrhea, ARI, and malaria as the significant predictors of underweight was run to test their prediction of underweight while controlling for sex and year of the study. Adjusted odds ratio from the multivariate analysis indicate that only diarrhea (AOR = 1.33, 95% CI [1.26, 1.41]; $p < 0.001$), and malaria (AOR = 1.10, 95% CI [1.04, 1.17]; $p < 0.001$) are significantly associated with underweight when sex and year of the study were controlled (see Table 4). This final model was statistically significant $p < 0.001$. This provides evidence to reject the null hypothesis that diarrhea does not have a relationship with underweight and to also reject the null hypothesis that malaria or fever does not have a relationship with underweight. However, there is no sufficient evidence to reject the null hypothesis that acute respiratory infections do not have a relationship with child underweight and the null hypothesis that measles infection does not have a relationship with underweight.

Stunting

Bivariate logistic regression for stunting showed that diarrhea, acute respiratory infections, and malaria were significant predictors of stunting. Diarrhea was the strongest individual predictor by increasing the odds of stunting by 23% (COR = 1.23; 95% CI [1.17, 1.28]; $p<0.001$). Acute respiratory infections increased the odds of stunting by 7% (COR = 1.07; 95% CI [1.02, 1.12]; $p<0.01$) while malaria increased the odds of stunting by 9% (COR = 1.09; 95% CI [1.04, 1.15]; $p<0.001$). The results showed that measles infection does not have a statistically significant effect on stunting (COR = 0.99; 95% CI [0.90, 1.09]; $p = 0.825$). A bivariate analysis of age group and sex to test whether they were important covariate or confounders showed both were significant covariates. Sex was significantly associated with stunting where females have reduced odds of being stunted (COR = 0.76, 95% CI [0.74, 0.79]; $p < 0.001$). The results, however, showed that the odds of being stunted among children above the age of 24 months increased by 7% (COR = 1.08, 95% CI [1.04, 1.12]; $p < 0.001$) when compared to children that are 24 months or younger. Bivariate analysis of calendar year and stunting showed that with every additional year the odds of children being stunted were reduced by 11% (COR = 0.89, 95% CI [0.87, 0.90]; $p < 0.001$).

A multivariate analysis of diarrhea, ARI and malaria while controlling for age group, sex, and year of the study showed that only diarrhea (AOR = 1.17, 95% CI [1.12, 1.24]; $p < 0.001$) and malaria (AOR = 1.08, 95% CI [1.02, 1.13]; $p < 0.01$) were statistically significant predictors of stunting. Age group and sex remained significant predictors of stunting in the multivariate analysis. This final model was statistically significant $p < 0.001$. Results of this analysis provide sufficient evidence to reject the null hypothesis that diarrhea does not have a relationship with stunting and the null hypothesis that malaria or fever does not have a relationship with stunting. However, the results do not provide sufficient evidence to reject the null hypothesis that ARI does not have a relationship with stunting and the null hypothesis that measles infections do not have a relationship with stunting.

Wasting

A bivariate analysis of ARI, malaria, and diarrhea with wasting showed that diarrhea increased the odds of wasting by 35% (COR =1.35; 95% CI [1.28, 1.42]; $p < 0.001$). ARI and malaria were also significant predictors of wasting where they increased the odds of being wasted by 18% (COR=1.18; 95% CI [1.12, 1.25] at p<0.001) and 17% (COR =1.17; 95% CI [1.10, 1.25] at p<0.001) respectively. Results also showed that measles infection was not a statistically significant predictor of wasting (COR = 1.08; 95% CI [0.96, 1.22]; p = 0.174).

Bivariate analysis of year of the study and wasting showed that calendar year was significantly associated with wasting with every additional year increasing the odds of wasting by 6% (COR = 1.06, 95% CI [1.04, 0.07]; p <0.001). In addition, a bivariate analysis of age group and sex to assess their relationship with wasting showed that both age group and sex were significant predictors of wasting (COR = 1.06; 95% CI [1.03, 1.11]; p <0.01); COR = 1.75; 95% CI [1.72, 1.78]; p <0.001 respectively).

A multivariate analysis of ARI malaria and diarrhea while controlling for age group, sex and year of study showed that all three factors were significant predictors of wasting (Diarrhea AOR = 1.30, 95% CI [1.22, 1.39]; p <0.01; Acute Respiratory Infections AOR = 1.10, 95% CI [1.03, 1.17]; p <0.01; Malaria AOR = 1.11, 95% CI [1.04, 1.18]; p <0.01) (see Table 4). Based on these results, there is sufficient evidence to reject the null hypothesis that diarrhea does not have a relationship with wasting and to reject the null hypothesis that malaria does not have a relationship with wasting. The evidence is also sufficient to reject the null hypothesis that ARI does not have a relationship with wasting. However, there isn’t sufficient evidence to reject the null hypothesis that measles infection does not have a relationship with wasting.

Table 4

Bivariate and Multivariate Analysis for Variables in Research Question Two (N= 60,856)

	Crude Odds Ratio	P>z	95% CI	**Adjusted Odds Ratio**	P>z	95% CI
Underweight						
Measles infection	1.01	0.859	0.91,1.12			
Diarrhea	1.41	<0.001*	1.34,1.48	1.33	<0.001*	1.26,1.41
ARI	1.17	<0.001*	1.12,1.23	1.04	0.142	0.99,1.10
Malaria	1.16	<0.001*	1.10,1.22	1.10	<0.001*	1.04,1.17
Age(>24)	1.03	0.164	0.99,1.07			
Sex (Female)	0.77	<0.001*	0.74,0.80	0.79	<0.001*	0.76,0.83
Year	0.95	<0.001*	0.93,0.96	1.06	<0.001*	0.93,0.96
Stunting						
Measles infection	0.99	0.825	0.90,1.09			
Diarrhea	1.23	<0.001*	1.17,1.28	1.17	<0.001*	1.12,1.24
ARI	1.07	< 0.01*	1.02,1.12	0.98	0.550	0.94,1.04
Malaria	1.09	<0.001*	1.04,1.15	1.08	< 0.01*	1.02,1.13
Age(>24)	1.08	<0.001*	1.04,1.12	1.12	<0.001*	1.07,1.17
Sex (Female)	0.76	<0.001*	0.74,0.79	0.79	<0.001*	0.76,0.82
Year	0.89	<0.001*	0.87,0.90	0.99	0.386	0.96,1.02
Wasting						
Measles infection	1.08	0.174	0.96,1.22			
Diarrhea	1.35	<0.001*	1.28,1.42	1.30	<0.001*	1.22,1.39
Acute Respiratory Infections	1.18	<0.001*	1.12,1.25	1.10	< 0.01*	1.03,1.17
Malaria	1.17	<0.001*	1.10,1.25	1.11	< 0.01*	1.04,1.18
Age(>24)	1.06	<0.01*	1.02,1.11	1.03	0.279	0.98,1.08
Sex (Female)	0.75	<0.001*	0.72,0.78	0.76	<0.001*	0.72,0.80
Year	1.06	<0.001*	1.04,1.07	1.09	<0.001*	1.06,1.13

*Statistically significant. Year and child's sex adjusted in all models; age adjusted in stunting and wasting.

Household Level Predictors of Undernutrition

RQ3: Are dietary diversity, child feeding (exclusive breastfeeding and feeding frequency), access to safe water, and access to health care associated with underweight, stunting, or wasting in SCS?

H_0: Underweight, stunting and wasting are not associated with dietary diversity ($H_0$5), child feeding practices[exclusive breastfeeding ($H_0$6) and minimum feeding frequency ($H_0$7)], access to safe water ($H_0$8) and access to health care disease ($H_0$9).

H_a: Underweight, stunting and wasting are associated with dietary diversity (H_a5), child feeding practices [exclusive breastfeeding (H_a6) and feeding frequency (H_a7)], access to safe water (H_a8) and access to health care disease (H_a9).

This question sought to establish factors that influence child undernutrition at the proximal or household level specifically dietary diversity, child feeding practices (exclusive breastfeeding and minimum frequency of feeding), access to safe water and access to health care. The gender of the household head and age of the mother were assessed as possible covariates while calendar year was controlled because of its demonstrated significant relationship with all the three forms of undernutrition in this study. Results of the analysis are presented in table 5.

HDDS is estimated using 12 main food groups that reflect the level of access to food and the quality of diet in the household (Coates et al., 2007). The mean HDDS score in this study is 4.97 (N = 41648) against an ideal score of 12 for adequacy in nutrition diversity. Child feeding practices are assessed for children that were 24 months or younger using two indicators; Exclusive breastfeeding up to 6 months and Minimum meal frequency (WHO, 2007). Only 3% of the children were exclusively breastfed up to 6 months of age while 40% received food a minimum number of times appropriate for their age. Forty-five percent of the children had access to safe water, while 43% had access to a sanitation facility. Of the children that reported sickness, the majority (30%) did not seek any assistance, 26% sought assistance from a private service provider, 9% used their own medication while 19 and 16% sought assistance from traditional healers or public health facilities respectively.

Bivariate logistic regression was conducted for HDDS, exclusive breastfeeding, minimum meal frequency, access to water, access to a sanitation facility, and health care as key underlying causes of undernutrition at household level. While factors like the mother's age and gender of the household head are not part of the nutritional causal framework, they are factors that could have an effect on household dynamics and therefore the nutritional status of children. The effect of these factors on underweight, stunting, and wasting was evaluated in bivariate analysis, and those that affected the odds of the outcome by at least 5% were controlled in the multivariate models.

Underweight

HDDS was found to be a significant predictor of underweight among all the children (COR = 0.93 CI [0. 92, 0.95]; p <0.001) as shown in Table 5. Among children aged 24 months or under, the odds of being underweight were reduced by 5% (COR = 0.95, CI [0.93, 0.97]; p <0.001) for every unit increase in the HDDS. Among children aged 24 months or more, the chances of being underweight were reduced by 8% (COR =

0.92, CI [0.91, 0.94]; p <0.001) for every unit increase in the HDDS. Exclusive breastfeeding reduced chances of underweight by 25% (COR = 0.75, CI [0.57, 0.98]; p <0.05) while achieving minimum meal frequency also reduced the odds of underweight by 25% (COR = 0.75, CI [0.68, 0.81]; p <0.001).

Overall, access to health care was not a statistically significant predictor of underweight (p <0.355), however among the different options of care, using own medication reduced the odds of underweight by 11% (COR = 0.89, 95% CI [0.80, 0.99]; p <0.05), when compared with not seeking any assistance. All the other care options did not have a statistically significant relationship with underweight. Access to safe water was overall a statistically significant predictor of underweight (COR = 0.79, CI [0.76, 0.83]; p <0.001).

Among children aged 24 months or under, access to safe water reduced the chances of underweight by 16% (COR = 0.84, CI [0.78, 0.91]; p <0.001) while chances of underweight were reduced by 23% among children above 24 months (COR = 0.77, CI [0.73, 0.82]; p <0.001). Access to sanitation facilities was also a significant predictor of underweight among all children (COR = 0.77, CI [0.74, 0.81]; p <0.001) with the odds of underweight reduced by 18% (COR = 0.82, CI [0.76, 0.89]; p <0.001) among those aged 24 months or under and reduced by 25% among those above 24 months.

Bivariate regression of household gender and mother's age with underweight as other potentially important covariates revealed that mothers' age did not influence underweight (COR = 1.00, CI [0.99, 1.0]; p <0.05) while the gender of the household head was not statistically significant (COR = 0.97, CI [0.92, 1.03]; p = 0.36). A multivariate regression of HDDS, minimum meal frequency, and access to safe water and access to sanitation facility as significant predictors of underweight was run to assess their effect in predicting underweight while controlling calendar year. As shown in Table 5, results of the analysis showed that only HDDS (AOR = 0.93, CI [0.88, 0.97]; p <0.01) and minimum meal frequency (AOR = 0.78, CI [0.67, 0.91]; p <0.01) remained statistically significant predictors of underweight while access to water and sanitation were no longer statistically significant. Hence there is enough evidence to reject the null hypothesis that HDDS does not have a relationship with underweight and to reject the null hypothesis that frequency of feeding children with complementary foods does not have a relationship with underweight. However, there isn't sufficient evidence to reject the null hypothesis that exclusive breastfeeding (6 months) does not have a relationship with underweight or reject the null hypothesis that access to health care does not have a relationship with underweight.

Table 5

Bivariate and Multivariate Analysis for Variables in RQ3 (N= 60,856)

Variables	**Crude Odds Ratio**	**P>z**	**95% CI**	**Adjusted Odds Ratio**	**P>z**	**95% CI**
Underweight						
Household Diet Score	0.93	<0.001*	0.92,0.95	0.93	<0.01*	0.88,0.97
Exclusive breastfeeding(Y)	0.75	< 0.05*	0.57,0.98	0.69	0.085	0.45,1.05
Meal Frequency (Y)	0.75	<0.001*	0.68,0.81	0.78	<0.01*	0.67,0.91
Access to safe water (Y)	0.79	<0.001*	0.76,0.83	0.93	0.367	0.79,1.09
Access to health care						
Own Medication	0.89	< 0.05*	0.80,0.99			
Traditional healer/Prayers	0.93	0.093	0.86,1.01			
Private Clinic/Pharmacy	0.99	0.867	0.92,1.07			
Public health Facility	1.04	0.432	0.95,1.13			
Access to sanitation (Y)	0.77	<0.001*	0.74,0.81	0.96	0.587	0.82,1.12

(table continues)

Variables	Crude Odds Ratio	P>z	95% CI	Adjusted Odds Ratio	P>z	95% CI
Mother's Age	1.00	< 0.05*	0.99,1.00			
Gender of the hh head(F)	0.97	0.360	0.92,1.03			
Year	0.95	<0.001*	0.93,0.96	0.95	0.380	0.86,1.06
Stunting						
Household Diet Score	0.98	<0.01*	0.97,0.99	1.01	0.740	0.97,1.04
Exclusive breastfeeding (Y)	0.79	0.066	0.61,1.02			
Min Meal Frequency (Y)	0.61	<0.001*	0.56,0.66	0.60	<0.001*	0.53,0.68
Access to safe water (Y)	0.83	<0.001*	0.79,0.86	0.86	< 0.05*	0.76,0.96
Access to health care						
Own Medication	1.03	0.615	0.93,1.13			
Traditional healer/Prayers	0.82	<0.001*	0.76,0.89			
Private Clinic/Pharmacy	1.02	0.650	0.95,1.09			
Public health Facility	1.19	<0.001*	1.10,1.29			
Access to sanitation (Y)	0.82	<0.001*	0.79,0.86	1.06	0.292	0.95,1.19
Mother's Age	0.99	<0.001*	0.99,0.99			
Gender of the hh head(F)	0.91	<0.01*	0.86,0.96	0.95	0.423	0.83,1.08
Year	0.89	<0.001*	0.87,0.90	0.86	<0.001*	0.80,0.92
Wasting						
Household Diet Score	0.94	<0.001*	0.93,0.96	0.96	<0.001*	0.94,0.98
Exclusive breast feeding (Y)	0.83	0.210	0.61,1.11			
Min Meal Frequency (Y)	0.91	0.054	0.83,1.00			
Access to safe water (Y)	0.89	<0.001*	0.84,0.94	0.89	<0.001*	0.83,0.95
Access to health care						
Own Medication	0.94	0.327	0.83,1.06			
Traditional healer/Prayers	1.13	<0.01*	1.03,1.24			
Private Clinic/Pharmacy	1.02	0.586	0.94,1.11			
Public health Facility	1.02	0.765	0.92,1.12			
Access to sanitation (Y)	0.91	<0.001*	0.86,0.96	0.93	<0.05*	0.87,1.00
Mother's Age	1.01	<0.01*	1.00,1.01			
Gender of the hh head(F)	1.00	0.889	0.94,1.08			
Year	1.06	<0.001*	1.04,1.07	1.06	<0.001*	1.03,1.10

hh - household*Statistically significant. All models adjusted for year. Gender of the household head was adjusted in the model for stunting.

Stunting

Results in Table 5 show that HDDS is a statistically significant predictor of stunting where children in households with higher diet diversity have reduced chances of being stunted; however, the effect on stunting is marginal (COR = 0.98, CI [0.97, 0.99]; p <0.01). Results further showed that exclusive breastfeeding was not a statistically significant predictor of stunting (COR = 0.79, CI [0.61, 1.02]; p = 0.066). However, minimum meal frequency reduced the odds of stunting by 39% (COR = 0.61, CI [0.56, 0.66]; p <0.001).

Access to safe water was found to be a statistically significant predator of stunting where chances of being stunted among children in households with access to a safe water source were reduced by 17% (COR = 0.83, CI [0.79, 0.86]; p <0.001). Similarly, access to sanitation facilities reduced the odds of stunting by 18% (COR = 0.82, CI [0.79, 0.86]; p <0.001). Among children older than 24 months, access to sanitation facilities reduced the odds of stunting by 21% (COR = 0.79, CI [0.75, 0.83]; p <0.001) compared to only 11% among children younger than 24 months (COR = 0.89, CI [0.82, 0.96]; p <0.01).

Overall, access to health care did not a have statistically significant relationship with stunting (p = 0.938). Children that were taken to traditional or religious leaders had reduced chances of being stunted when compared to those that did not seek any health care (COR = 0.82, CI [0.76, 0.89]; p <0.001). However, those that sought care from public health facilities were at greater odds of being stunted (COR = 1.19, CI [0.10, 0.29]; p <0.001) when compared to those that did not seek any health care assistance. Children that were treated with own medicine at home and those that were taken to private health clinics were not significantly different from those that did not seek any health care assistance.

Gender of the household head was found to significantly predict stunting where children in households that were headed by women have 9% lower chances of being stunted (OR = 0.91, CI [0.86, 0.96]; $p < 0.01$) compared to those in households headed by men. Likewise, mothers' age significantly predicted stunting where children of older mothers had reduced chances of being stunted, but the effect was marginal (COR = 0.99, CI [0.986, 0.993]; $p < 0.001$). Binomial logistic regression with each of the significant predictors of stunting was conducted to test whether gender of the household head and mother's age were confounding factors. Results of the analysis revealed that neither household head nor age caused a change in the odds ratio of HDDs, access to safe water, minimum meal frequency and access to sanitation facilities of up to 10% implying that none of the factors had a confounding effect. Age of the mother was therefore left out of the multivariate model, but gender of the household head was included because results showed that it was a statistically significant covariate.

A multivariate logistic regression of the factors that were statistically significant in predicting stunting in the bivariate analysis was run to control for their individual effects. The model included HDDS, exclusive breastfeeding, minimum meal frequency, access to safe water, access to sanitation facilities and access to health care while controlling for gender of the household head and calendar year. While mother's age was statistically significant in predicting stunting, it was not controlled in the final model because its impact on stunting was marginal. The multivariate logistic regression model showed that only minimum meal frequency and access to safe water remained statistically significant predictors of stunting. The odds of stunting among children that were given food a minimum number of times required for their daily consumption was reduced by 40% (AOR = 0.60, CI [0.53, 0.68]; p <0.001). While the odds of stunting among children in households that had access to safe water were reduced by 14% (AOR = 0.86, CI [0.76, 0.96]; p <0.01) (see Table 5).

Results of the multivariate regression provided sufficient evidence to reject the null hypothesis that access to safe water did not have a relationship with stunting and evidence to reject the null hypothesis that the frequency of feeding children with complementary foods did not have a significant relationship with stunting. The results, however, did not provide sufficient evidence to reject the null hypothesis that exclusive breastfeeding as a child feeding practice did not have a relationship with stunting or reject the null hypothesis that household diet diversity did not have a relationship with stunting. In addition, the null hypothesis that access to health care did not have a relationship with child stunting could not be rejected.

Wasting

Bivariate analysis of HDDS and wasting showed that HDDS was a statistically significant predictor of wasting where the odds of wasting were reduced for children in households with a higher diet diversity **(C**OR = 0.94, CI [0.93, 0.96]; p <0.001). A unit increase in HDDS decreased the odds of wasting by 7% among children above 24 months compared to only 4% among children aged 24 months or younger. Results further showed that exclusive breastfeeding and minimum meal frequency were not statistically significant predictors of wasting (see Table 5). However, access to safe water and access to sanitation facilities were statistically significant predictors of wasting. Access to safe water reduced the odds of wasting by only 11% (COR = 0.89, CI [0.84, 0.94]; $p < 0.001$) while access to sanitation facilities reduced chances of being wasted by 9% (COR = 0.91, CI [0.86, 0.96]; $p < 0.001$). Access to health care was not a statistically significant predictor of wasting ($p = 0.272$).

Bivariate logistic regression of mother's age and gender of household head were conducted to determine if the factors were important covariates. Results showed that both mother's age and gender of household head did not have a statistically significant relationship with wasting. Multivariate regression of HDDS, access to safe water, and access to sanitation as factors that were statistically significant predictors of wasting in the bivariate analysis was conducted while controlling for calendar year. Results of the regression showed that all the three factors remained statically significant predictors of wasting: HDDS (AOR = 0.96, CI [0.94, 0.98]; $p < 0.001$); access to safe water (AOR = 0.89, CI [0.83, 0.95]; $p < 0.001$) and access to sanitation (AOR = 0.93, CI [0.87, 1.00]; $p < 0.05$) (see Table 5). The multivariate regression model was significant at $p<0.001$ and provided sufficient evidence to reject the null hypothesis that dietary diversity did not have a relationship with wasting and also to reject the null hypothesis that access to safe water did not have a relationship with child wasting. The results also provided sufficient evidence to reject the null hypothesis that access to sanitation did not have a relationship with wasting. Results, however, do not provide sufficient evidence to reject the null hypothesis that child feeding both in terms of exclusive breastfeeding and frequency of feeding children with complementary foods does not a relationship with child wasting. The evidence was also insufficient to reject the null hypothesis that access to health care did not have a relationship with child wasting.

Society Level Predictors of Undernutrition

RQ4: Is the area of residence, livelihood system, and conflict associated with underweight, stunting, or wasting in SCS?

H_0: Underweight, stunting and wasting vary by area of residence ($H_0$10), Livelihood system ($H_0$11) and armed conflict ($H_0$12)

H_a: Underweight, stunting and wasting do not vary by area of residence (H_a10), Livelihood system (H_a11) and armed conflict (H_a12)

Area of residence was assessed using region where different regions have different social economic characteristics that affect children's nutrition status differently. Livelihood systems were assessed using five groups that are used to categorize livelihoods in Somalia: pastoralists, agro-pastoralist, riverine, urban and IDP. Conflict was measured by the number of conflict events that were reported over the study period. The conflict data was accessed from ACLED which collects data on the number of conflict events reported on a daily basis across different locations. The number of conflict events reported in the areas covered in this study was aggregated to a biannual count in line with the frequency of the nutrition surveys.

Underweight

Bivariate analysis of region and underweight showed that children living in Bay, Gedo and Bakool had higher odds of underweight (Bay -COR = 1.67, CI [1.32, 2.10]; p

<0.001; Gedo -COR = 1.59, CI [1.27, 1.98]; p <0.001; Bakool- COR = 1.51, CI [1.20, 1.90]; p <0.001) when compared with children living in Banadir region where prevalence of underweight was lowest (see Table 6). Children living in Bay had the highest odds of being underweight. Overall results showed that region was a statistically significant predictor of underweight. Livelihood system was also a significant predictor of underweight according to the results of bivariate analysis. When compared to pastoral populations that had less fluctuations in the prevalence of underweight, the odds of being underweight were higher among agro-pastoral (COR = 1.26, CI [1.20, 1.33]; p <0.001) and riverine populations (COR = 1.19, CI [1.12, 1.25]; p <0.001) but lower among the urban and IDP populations (see Table 6). Bivariate analysis of conflict and underweight showed that conflict was not a significant predictor of underweight (COR = 1.00, CI [1.00, 1.00]; p = 0.171).

A multivariate regression of region and livelihood as significant predictors of underweight in the bivariate analysis was conducted. Calendar year was controlled in this model because of its significant relationship with underweight. Results showed that both region and livelihood remained statistically significant predictors of underweight. Further, the results also showed that only the odds of underweight in Bay were statistically significant and different from Banadir. In terms of livelihoods, the odds of underweight remained higher and statistically significant among agro-pastoralist and riverine populations when compared to pastoralists but lower in urban populations in the multivariate analysis.

Further, the odds of wasting among IDP populations were no longer statistically significant. The multivariate model was statistically significant ($p < 0.001$). Based on the results of the multivariate analysis, there was sufficient evidence to reject the null hypothesis that area of residence in terms of geographical region does not have a relationship with underweight and to also reject the null hypothesis that livelihood system does not have a relationship with underweight. With the bivariate analysis showing that conflict was not a significant predictor of underweight there wasn't sufficient evidence to reject the null hypothesis that conflict does not have a relationship with underweight.

Stunting

Results from the bivariate analysis showed that region was a significant predictor of stunting only among children living in Galgaduud, M.Juba and Bay. When compared to children living in Banadir, children living in Galgaduud were 32% (COR = 0.68, CI [0.55, 0.82]; $p < 0.001$) less likely to be stunted, while children living in M.Juba and Bay were 41% (COR = 1.40, CI [1.16, 1.72; $p < 0.01$) and 23% (COR =1.23, CI [1.01, 1.50]; $p < 0.05$) respectively, more likely to be stunted (see Table 6). Overall, region was a statistically significant predictor of stunting. Livelihood system significantly predicted stunting among children living in all four livelihood systems with the odds of being stunted being greater among agropastoralists, riverine and IDPS but lower among urban, when compared to pastoralist (see Table 6). The odds of being stunted were highest in M. Juba (COR = 1.41, CI [1.16, 1.72]; $p < 0.01$).

A bivariate analysis of conflict showed that it was not a statistically significant predictor of stunting. Conflict was therefore not included in the multivariate model with region, livelihood and calendar year as a control. Results from the multivariate analysis showed that region was a significant predictor of stunting in all the regions while livelihood was only statistically significant among agropastoral, riverine and urban populations (see Table 6). A test of contrasts after the multivariate regression model showed that both region and livelihood remained statistically significant predictors of stunting. The multivariate model was significant ($p < 0.001$) giving sufficient evidence to reject the null hypothesis that region does not have a relationship with stunting and the hypothesis that livelihood system does not have a relationship with stunting. The evidence was however not sufficient to reject the null hypothesis that conflict did not have a relationship with stunting.

Wasting

Bivariate analysis of region showed that region was a statistically significant predictor of wasting. When compared to children living in Banadir region, children in all the regions were more likely to be wasted with children in Gedo, M.Shabelle, and Bay at least two times more likely to be wasted (Gedo COR = 2.60, CI [1.94, 3.48]; $p < 0.001$: M.Shabelle COR = 2.07, CI [1.53, 2.78]; $p < 0.001$): Bay COR = 2.09, CI [1.55, 2.83]; $p < 0.001$) (see Table 6). Livelihood system was also a statistically significant predictor of wasting where compared to pastoralists, the odds of being wasted were lower in all the livelihoods. Similar to underweight and stunting, bivariate analysis of conflict showed that it did not have any effect on wasting. A multivariate regression model of region and livelihood while controlling for a year showed that both region and livelihood remained a statically significant predictor of wasting.

While the effect of region was statistically significant for all regions, the effect of livelihood system only remained statistically significant for agropastoralists, riverine and IDPs populations. The multivariate model was significant (p <0.001) which provides sufficient evidence to reject the null hypothesis that area of residence (region) did not have a relationship with wasting and to also reject the hypothesis that livelihood system does not have a relationship wasting.

Table 6

Bivariate and Multivariate Analysis for Variables in RQ4 (N= 60,856)

	Crude Odds Ratio	**P>z**	**95% CI**	**Adjusted Odds Ratio**	**P>z**	**95% CI**
Underweight						
Region						
Bakool	1.51	<0.001*	1.20,1.90	1.07	0.625	0.82,1.39
Hiran	1.34	<0.05*	1.07,1.68	0.98	0.893	0.76,1.27
Galgaduud	1.14	0.254	0.91,1.44	1.02	0.871	0.79,1.33
M.Shabelle	1.34	<0.05*	1.06,1.68	1.01	0.967	0.78,1.30
L.Juba	1.08	0.492	0.86,1.37	0.84	0.205	0.65,1.10
M.Juba	1.40	<0.01*	1.11,1.75	1.01	0.913	0.78,1.32
L.Shabelle	1.26	<0.05*	1.01,1.58	1.00	0.973	0.79,1.28
Gedo	1.59	<0.001*	1.27,1.98	1.25	0.094	0.96,1.61
Bay	1.67	<0.001*	1.32,2.10	1.32	<0.05*	1.01,1.72
Livelihood						
Agropastoral	1.26	<0.001*	1.20,1.33	1.24	<0.001*	1.17,1.31
Riverine	1.19	<0.001*	1.12,1.25	1.19	<0.001*	1.11,1.27
Urban	0.41	<0.001*	0.26,0.66	0.48	<0.01*	0.29,0.80
IDP	0.90	<0.01*	0.82,0.98	1.03	0.698	0.90,1.16
Conflict	0.95	<0.001*	1.00,1.00			
Year	0.94	<0.001*	0.93,0.96	0.96	<0.001*	0.94,0.98
Stunting						
Region						
Bakool	0.99	0.956	0.81,1.22	0.51	<0.001*	0.41,0.65
Hiran	0.83	0.064	0.69,1.01	0.40	<0.001*	0.32,0.50
Galgaduud	0.68	<0.001*	0.55,0.82	0.52	<0.001*	0.41,0.66
M.Shabelle	0.96	0.693	0.79,1.17	0.51	<0.001*	0.40,0.64

(table continues)

	Crude Odds Ratio	P>z	95% CI	Adjusted Odds Ratio	P>z	95% CI
L.Juba	0.99	0.891	0.81,1.20	0.57	<0.001*	0.45,0.72
M.Juba	1.41	<0.01*	1.16,1.72	0.67	<0.01*	0.53,0.84
L.Shabelle	1.17	0.113	0.96,1.42	0.70	<0.01*	0.56,0.86
Gedo	0.90	0.283	0.74,1.09	0.51	<0.001*	0.41,0.64
Bay	1.23	< 0.05*	1.01,1.50	0.73	< 0.05*	0.58,0.93
Livelihood						
Agropastoral	1.59	<0.001*	1.51,1.67	1.45	<0.001*	1.37,1.54
Riverine	1.81	<0.001*	1.71,1.91	1.75	<0.001*	1.64,1.86
Urban	0.49	<0.01*	0.32,0.77	0.38	<0.001*	0.24,0.61
IDP	1.24	<0.001*	1.14,1.34	0.90	0.092	0.80,1.02
Conflict	1.00	< 0.05*	1.00,1.00			
Year	0.89	<0.001*	0.87,0.90	0.95	<0.001*	0.93,0.96
Wasting						
Region						
Bakool	1.85	<0.001*	1.37,2.51	2.52	<0.001*	1.80,3.52
Hiran	1.97	<0.001*	1.47,2.64	2.89	<0.001*	2.09,4.00
Galgaduud	1.79	<0.001*	1.33,2.41	2.10	<0.001*	1.51,2.92
M.Shabelle	2.07	<0.001*	1.53,2.78	2.76	<0.001*	1.99,3.83
L.Juba	1.66	<0.01*	1.23,2.24	2.21	<0.001*	1.59,3.08
M.Juba	1.63	<0.01*	1.21,2.20	2.38	<0.001*	1.71,3.31
L.Shabelle	1.67	<0.01*	1.24,2.24	2.03	<0.001*	1.49,2.77
Gedo	2.60	<0.001*	1.94,3.48	3.48	<0.001*	2.52,4.81
Bay	2.09	<0.001*	1.55,2.83	2.80	<0.001*	2.00,3.92
Livelihood						
Agropastoral	0.91	<0.01*	0.86,0.96	0.93	< 0.05*	0.88,1.00
Riverine	0.79	<0.001*	0.74,0.84	0.79	<0.001*	0.73,0.85
Urban	0.59	< 0.05*	0.38,0.92	0.87	0.559	0.54,1.39
IDP	0.81	<0.001*	0.73,0.89	1.30	<0.001*	1.14,1.49
Conflict	1.00	<0.001*	1.00,1.00			
Year	1.06	<0.001*	1.04,1.07	1.04	<0.001*	1.02,1.06

*Statistically significant. All models adjusted for year.

RQ5: Are dietary diversity, disease, child feeding practices, access to safe water, access to health care, displacement, area of residence, livelihood system, and armed conflict significant predictors of underweight, stunting, and wasting in SCS between 2007 and 2012, when all levels of exposure are considered simultaneously?

H_0: Dietary diversity, disease, child feeding practices, access to safe water and access to health care displacement, the area of residence, livelihood system and conflict do not have a relationship with underweight, stunting, and wasting when all levels of exposure are considered simultaneously.

H_a: Dietary diversity, disease, child feeding practices, access to safe water and access to health care displacement, the area of residence, livelihood system and conflict have a relationship with underweight, stunting, and wasting when all levels of exposure are considered simultaneously.

To answer RQ5, a single model for each of the outcome variables was run using factors that were found to be significant in predicting underweight, stunting, and wasting at child, household, and society level.

Underweight

The single combined model for underweight had diarrhea, ARI, malaria, child gender, household diet score, region and livelihood as significant predictors from the child, household and society level analysis while controlling for year. Results showed that when all the significant factors at different levels of exposure were considered, diarrhea, malaria, child gender, household diet score, region, and livelihood system remained significant predictors of underweight (see Table 7). Diarrhea increased the odds of being underweight by 42% (AOR = 1.41, CI [1.24, 1.62]; p <0.001). The results also showed that when compared to male children, the odds of underweight were reduced by 27% (AOR = 0.56, CI [0.56, 1.70]; p <0.01) among female children. Additionally, an increase in household diet by one unit decreased the odds of underweight 16% (AOR = 0.94, CI [0.91, 0.98]; p <0.01) while the odds of underweight among children that received food the required number of times were reduced 25% (AOR = 0.85, CI [0.75, 0.96]; p <0.05.

While region was overall a statistically significant predictor of underweight (p<0.001), within specific regions, there was no statistically significant difference in odds of underweight between children in any of the regions and children in Banadir when all the levels of exposure were considered. The effect of the livelihood system was statistically significant predictor of underweight when all levels of exposure (p<0.001), considered however between the livelihoods only among riverine and IDP populations were significantly different from pastoralists as a comparison group. The odds of underweight were increased by 51% (AOR = 1.51, CI [0.23, 1.84]; p <0.01) among riverine and by 47% (AOR = 1.47, CI [1.04, 2.07]; p <0.05). This final model was significant at p <0.001 meaning that there is sufficient evidence to reject the null hypothesis that diarrhea, malaria, child gender, household diet score, region, and livelihood system have a relationship with underweight when all factors that influence underweight at individual child level, household, and society level are considered.

Table 7

Association between Child, Household and Society Factors with Underweight When All Levels of Exposure are Considered Simultaneously (N = 60,856)

Variable	COR	P>z	95% CI	AOR	P>z	95% CI
Child level factors						
Diarrhea	1.41	<0.001*	1.34,1.48	1.42	<0.001*	1.24,1.62
Malaria	1.16	<0.001*	1.10,1.22	1.00	0.976	0.87,1.15
Sex (Female)	0.77	<0.001*	0.74,0.80	0.63	<0.001*	0.56,0.70
Household level factors						
Household Diet Score	0.93	<0.001*	0.92,0.95	0.94	<0.01*	0.91,0.98
Min Meal Frequency	0.75	<0.001*	0.68,0.81	0.85	<0.05*	0.75,0.96
Society level factors						
Region						
Bakool	1.51	<0.01*	1.20,1.90	1.83	0.090	0.91,3.67
Hiran	1.34	<0.05*	1.07,1.68	0.84	0.530	0.49,1.44
Galgaduud	1.14	0.254	0.91,1.44	0.94	0.847	0.50,1.77
M.Shabelle	1.34	<0.05*	1.06,1.68	0.69	0.200	0.40,1.21
L.Juba	1.08	0.492	0.86,1.37	1.08	0.791	0.61,1.92
M.Juba	1.40	0.004	1.11,1.75	1.32	0.325	0.76,2.32
L.Shabelle	1.26	0.044	1.01,1.58	1.15	0.577	0.71,1.86
Gedo	1.59	<0.001*	1.27,1.98	0.97	0.903	0.55,1.69
Bay	1.67	<0.001*	1.32,2.10	1.38	0.246	0.80,2.40
Livelihood						
Agropastoral	1.26	<0.001*	1.20,1.33	1.16	0.137	0.95,1.42
Riverine	1.19	<0.001*	1.12,1.25	1.51	<0.001*	1.23,1.84
Urban	0.41	<0.001*	0.26,0.66			
IDP	0.90	0.019*	0.82,0.98	1.47	<0.05*	1.04,2.07
Year	0.95	<0.001*	0.93,0.96	1.01	0.81	0.91,1.12

*Statistically significant, All models adjusted for year.

Stunting

Diarrhea, malaria, and gender of the child were significant predictors of stunting at child level while minimum meal frequency, access to safe water, and access to sanitation facilities were the significant variables at household level. Region and livelihood system were the significant predictors at society level. When all the factors that were significant predictors of stunting at the different levels were used as a single model, only child gender, minimum meal frequency, region, and livelihood remained statistically significant predictors of stunting (see Table 8).

Results showed that the odds of stunting were reduced by 33% (AOR = 0.67, CI [0.60, 0.74]; $p < 0.001$) among female children and reduced by 39% (AOR = 0.61, CI [0.54, 0.69]; $p < 0.001$) among children that received minimum frequency of feeding required for their age. The overall effect of region on stunting could not be tested in this model because of missing data in some of the observations. However, when compared to Banadir, the odds of stunting were only significantly different in Hiran (AOR = 0.49, CI 0.28, 0.85]; $p < 0.05$), Galgadud (AOR = 0.44, CI [0.25, 0.79]; $p < 0.01$), M. Shabelle (AOR = 0.56, [CI 0.32, 0.98]; $p < 0.05$). The overall effect of livelihood was also not testable; but between livelihoods, agropastoralist and riverine populations were significantly different from pastoralists where the odds of stunting were increased by 31% among the agropastorals (AOR = 1.31, CI [0.12, 0.55]; $p < 0.01$) and increased by 54% among the riverine (AOR = 1.54, CI [0.28, 0.85]; $p < 0.001$). The results, therefore, provide evidence to reject the null hypothesis that minimum meal frequency, region, and livelihood have a relationship with stunting when all the predators of stunting at child, household, and society level are considered.

Table 8

Association between Child, Household, and Society Factors with Stunting When All Levels of Exposure are Considered Simultaneously (N = 60,856)

Variables	**Crude Odds Ratio**	P>z	95% CI	**Adjusted Odds Ratio**	P>z	95% CI
Child level factors						
Diarrhea	1.23	<0.001*	1.17,1.28	1.07	0.290	0.94,1.21
Malaria	1.09	<0.001*	1.04,1.15	0.94	0.399	0.82,1.08
Sex (Female)	0.76	<0.001*	0.74,0.79	0.67	<0.001*	0.60,0.74
Household level factors						
Min Meal Frequency	0.61	<0.001*	0.56,0.66	0.61	<0.001*	0.54,0.67
Access to safe water	0.83	<0.001*	0.79,0.86	1.00	0.946	0.87,1.14
Society level factors						
Region						
Bakool	0.99	0.956	0.81,1.22	0.66	0.257	0.32,1.33
Hiran	0.83	0.064	0.69,1.01	0.49	<0.05*	0.28,0.85
Galgaduud	0.68	<0.001*	0.55,0.82	0.44	<0.01*	0.25,0.79
M.Shabelle	0.96	0.693	0.79,1.17	0.56	<0.05*	0.32,0.98
L.Juba	0.99	0.891	0.81,1.20	0.67	0.173	0.37,1.19
M.Juba	1.41	<0.01*	1.16,1.72	0.76	0.345	0.43,1.34
L.Shabelle	1.17	0.113	0.96,1.42	0.67	0.104	0.42,1.08
Gedo	0.90	0.283	0.74,1.09	0.65	0.128	0.37,1.13
Bay	1.23	<0.05*	1.01,1.50	0.99	0.962	0.56,1.75
Livelihood						
Agropastoral	1.59	<0.001*	1.51,1.67	1.31	<0.01*	1.11,1.54
Riverine	1.81	<0.001*	1.71,1.91	1.54	<0.001*	1.28,1.85
Urban	0.49	<0.01*	0.32,0.77			
IDP	1.24	<0.001*	1.14,1.34	1.15	0.418	0.82,1.60
Season (Gu)	1.10	<0.001*	1.06,1.15	1.12	0.332	0.89,1.39
Year	0.89	<0.001*	0.87,0.90	0.92	0.709	0.58,1.44

*Statistically significant; All models adjusted for year.

Table 9

Association between Child, Household, and Society Factors with Wasting When All Levels of Exposure are Considered Simultaneously

Variables	**Crude Odds Ratio**	P>z	95% CI	**Adjusted Odds Ratio**	P>z	95% CI
Child level factors						
Diarrhea	1.35	<0.001*	1.28,1.42	1.31	<0.001*	1.21,1.42
ARI	1.18	<0.001*	1.12,1.25	1.06	0.187	0.97,1.15
Malaria	1.17	<0.001*	1.10,1.25	1.17	<0.001*	1.08,1.28
Age(months)	1.01	<0.001*	1.00,1.01			
Sex (Female)	0.75	<0.001*	0.72,0.78	0.75	<0.001*	0.70,0.80
Household level factors						
Household Diet Score	0.94	<0.001*	0.93,0.96	0.97	<0.001*	0.94,0.99
Access to water	0.89	<0.001*	0.84,0.94	1.00	0.963	0.92,1.09
Access to sanitation	0.91	<0.001*	0.86,0.96	0.96	0.306	0.88,1.04
Society level factors						
Region						
Bakool	1.85	<0.001*	1.37,2.51	1.55	0.053	1.00,2.42
Hiran	1.97	<0.001*	1.47,2.64	1.81	<0.001*	1.17,2.78
Galgaduud	1.79	<0.001*	1.33,2.41	1.60	<0.05*	1.00,2.54
M.Shabelle	2.07	<0.001*	1.53,2.78	1.70	<0.05*	1.09,2.63
L.Juba	1.66	<0.01*	1.23,2.24	1.48	0.084	0.95,2.31
M.Juba	1.63	<0.01*	1.21,2.20	1.64	<0.05*	1.05,2.57
L.Shabelle	1.67	0.001*	1.24,2.24	1.52	<0.05*	1.02,2.28
Gedo	2.60	<0.001*	1.94,3.48	2.03	<0.01*	1.30,3.17
Bay	2.09	<0.001*	1.55,2.83	1.89	<0.01*	1.22,2.94
Livelihood						
Agropastoral	0.91	<0.01*	0.86,0.96	0.99	0.912	0.90,1.10
Riverine	0.79	<0.001*	0.74,0.84	0.81	<0.01*	0.72,0.92
Urban	0.59	<0.05*	0.38,0.92			
IDP	0.81	<0.001*	0.73,0.89	1.04	0.781	0.81,1.32
Year	1.06	<0.001*	1.04,1.07	1.12	<0.001*	1.06,1.18

*Statistically significant; All models adjusted for year

Wasting

Of the factors that had a relationship with wasting at child level, only diarrhea, malaria, and gender were found statistically significant in the multivariate analysis. At the household level, only household diet score and minimum meal frequency were statistically significant while region and livelihood system were significant at society level. A single model of these factors revealed that diarrhea, malaria, household diet score, region, and livelihood system remained statistically significant predictors of wasting (see Table 9). Diarrhea increased the odds of wasting by 31% (AOR = 1.31, CI [0.21, 0.42; $p<0.001$) while malaria increased the odds of wasting by 17% (AOR = 1.17, CI [1.08, 1.28]; $p<0.001$). Female children were less likely to be wasted when compared to boys (AOR = 0.75, CI [0.70, 0.80]; $p<0.001$) while children that were in households with a higher diet diversity score were less likely to suffer from wasting (AOR = 0.97, CI [0.94, 0.99]; $p < 0.01$).

Overall, region was a statistically significant predictor of wasting ($p <0.001$). Compared to Banadir, the odds of wasting were significantly higher in all regions except Bakool and Lower Juba (see Table 9). The odds of wasting in Gedo were more than twice the odds of being wasted in Banadir (AOR = 2.03, CI [0.21, 0.42]; $p<0.001$). Livelihood was a significant predictor of stunting in riverine populations where the odds of being wasted were reduced by 19% (AOR = 0.81, CI [0.72, 0.92]; $p<0.01$) when compared with pastoral populations. Results from this analysis provide evidence to reject the null hypothesis that diarrhea, malaria, HDDS, region and livelihood system have a relationship with wasting when other factors that influence wasting at child, household and society level are considered.

Trends in Predictors of Underweight, Stunting, and Wasting

RQ6: How do predictors of underweight, stunting, and wasting in SCS change between 2007 and 2012?

GEE of predictors of underweight among children under the age of 5 years revealed that in the context of SCS, diarrhea, and malaria were the statistically significant predictors of underweight at individual child level. At household level, the analysis revealed that household diet score and minimum meal frequency were the statistically significant predictors of underweight while geographical region and livelihood system were the statistically significant predictors of underweight at society level. A linear regression of the significant predictors of underweight showed that diarrhea had a declining trend ($R^2 = 0.47$), but it was not statistically significant ($p = 0.131$) while no trend was observed for malaria ($R^2 = 0.02$,) and meal frequency ($R^2 = 0.007$). Figure 11 shows the trend of the significant predictors of underweight in relation to the prevalence of underweight.

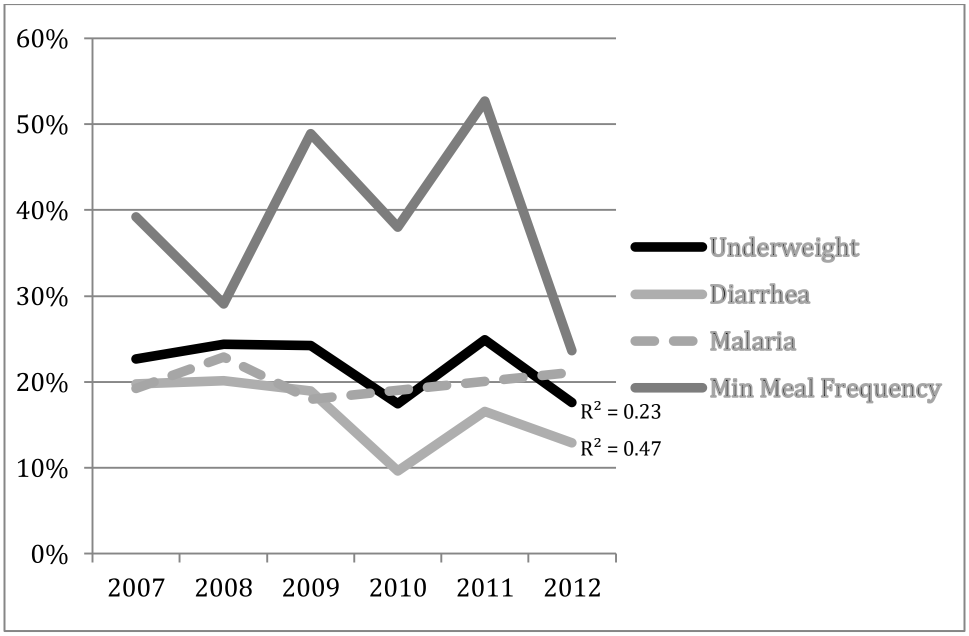

Figure 11. Trend of underweight and significant predictors.

The trend of diarrhea is similar to the trend of underweight, where a decrease in the prevalence in diarrhea corresponds with a decrease in the prevalence of underweight. The trend in the prevalence of malaria is less matched with the prevalence of underweight. The trend in minimum meal frequency is was not statistically significant or meaningful when compared to the trend in underweight.

The outcome of GEE of the predictors of stunting showed that diarrhea, ARI, and malaria were the statistically significant predictors of stunting at the individual child level while minimum meal frequency and access to safe water were statistically significant predictors at the household level. Geographical region, season, and year were statistically significant predictors of stunting at society level. A linear regression of the significant predictors of stunting showed that diarrhea had a declining trend (R^2=0.47), but it was not statistically significant (p = 0.131) while no trend was observed for malaria (R^2=0.02,) and meal frequency (R^2=0.007). ARI had a statistically significant declining trend (R^2=0.82; $p < 0.05$) while access to safe water and access to sanitation had statistically significant increasing trends (R^2=0.96; $p<0.001$) and (R^2=0.67; $p<0.05$) respectively. Figure 12 shows a plot of the significant predictors of stunting in relation to the prevalence of stunting. Stunting had a statistically significant decreasing trend (R^2=0.73; $p<0.05$).

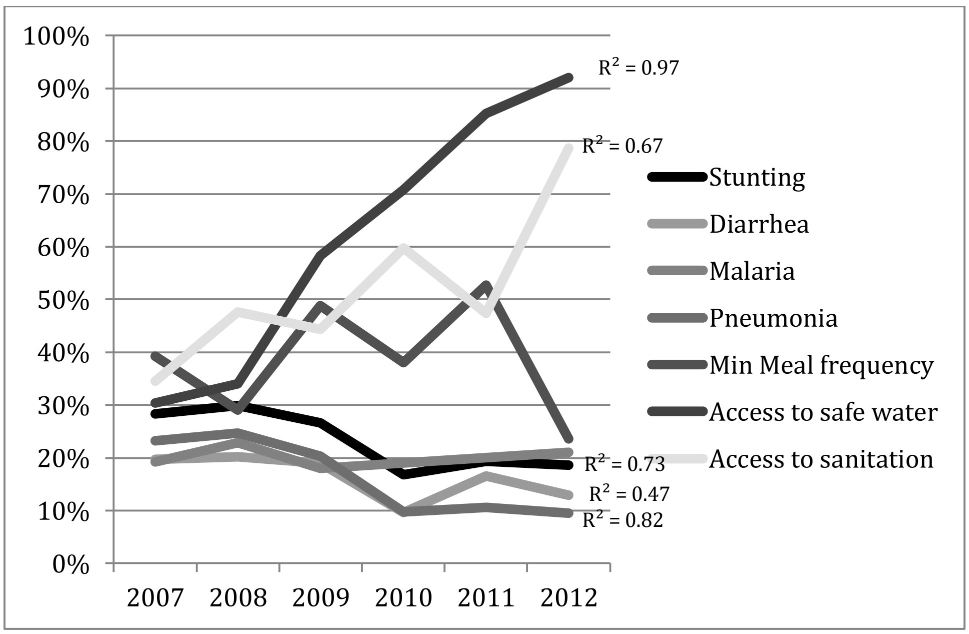

Figure 12. Trend of stunting and significant predictors.

GEE of predictors of wasting showed that wasting was significantly predicted by ARI, malaria, and diarrhea at individual child level while HDDS, access to safe water, and access to sanitation significantly predicted wasting at household level. Region and year were also statistically significant predictors of wasting. A linear regression of the significant predictors of wasting showed that diarrhea had a declining trend (R^2=0.47), but it was not statistically significant ($p = 0.131$) while no trend was observed for malaria

(R^2=0.02,) and meal frequency (R^2=0.007). ARI had a statistically significant declining trend (R^2=0.82; $p < 0.05$) while access to safe water and access to sanitation had statistically significant increasing trends (R^2=0.97; $p<0.001$) and (R^2=0.67; $p<0.05$) respectively. Wasting had an increasing trend, but it was not statistically significant (R^2=0.28; p= 0.285). Figure13 shows a plot of significant predictors of wasting and the prevalence of wasting.

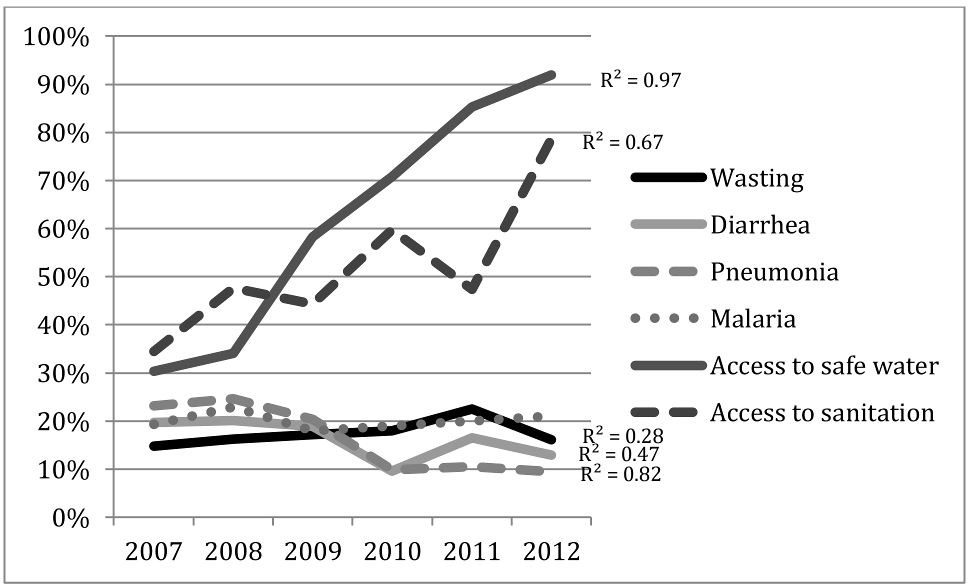

Figure 13. Trend of wasting and significant predators of wasting.

Summary

Findings from this study showed that overall, from 2007 to 2012 in SCS, there was statistically significant declining trend in the prevalence in stunting (R^2 = 0.73; p < 0.05), a declining but statistically insignificant trend in underweight (R^2 = 0.23; p = 0.339) and an increasing trend in wasting that was not statistically significant (R^2 = 0.28; p = 0.285). Within the age groups, there was no observable trend of underweight among children aged 24 months or younger while among children above 24 months, the observed trend was not statistically significant (R^2 = 0.61, p = 0.066). Further, results showed a weak decreasing underweight trend among urban and pastoral populations, but neither was statistically significant while there was no observable trend among the other populations.

Stunting had a decreasing trend among both age groups but the trend was stronger and statistically significant among children above 24 months old (R^2 = 0.81, $p < 0.05$). In addition, stunting showed a decreasing trend among all the livelihoods except among agropastoralists, where there was no observed trend. The stunting trend was stronger among pastoral (R^2 = 0.92; $p < 0.01$) and urban populations (R^2 = 0.997; $p < 0.05$). Wasting showed an increasing trend among both age groups, with the trend being stronger among children under 24 months or younger. However, the trend was not statistically significant in any of the age groups. Further, wasting had an increasing trend in all the livelihoods except among the urban population where it had a decreasing trend. However, none of the trends in wasting was statistically significant.

Diarrhea, malaria, and gender were found to be significant predictors of underweight at the child level while household diet diversity and meal frequency were the significant predictors of underweight at the household level. At society level, results showed that region and livelihood system were the significant predictors of underweight. In regard to stunting, results showed that acute respiratory infections (ARI), diarrhea and malaria were significant predictors at the child level while meal frequency and access to water were the significant predictors at the household level. Acute respiratory infections

(ARI), diarrhea and malaria were also the significant predictors of wasting at child level while diet diversity, meal frequency, and access to sanitation were the significant predictors of wasting at the household level. Geographical region and livelihood system were the significant predictors of underweight, stunting, and wasting at the society level.

When all the levels of exposure (child, household and society level) were considered simultaneously, diarrhea, child gender, diet diversity, meal frequency, region, and livelihood system were found to be the statistically significant predictors of underweight. Similarly, when all the levels of exposure were considered, the statistically significant predictors of stunting were child gender, meal frequency, and livelihood system. Wasting was significantly predicted by diarrhea, malaria, diet diversity, region, and livelihood system when all the levels of exposure were considered simultaneously. A linear regression of the significant predictors of undernutrition (underweight, stunting and wasting) showed that diarrhea had a declining trend (R^2=0.47), but it was not statistically significant ($p = 0.131$) while no trend was observed for malaria (R^2=0.02, p=0.862) and meal frequency (R^2=0.007, p =0.871). ARI had a statistically significant declining trend (R^2=0.82; $p < 0.05$) while access to safe water and access to sanitation had statistically significant increasing trends (R^2=0.97; $p<0.001$) and (R^2=0.67; $p<0.05$) respectively. Implications of the results of this study are discussed in chapter 5.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The main purpose of this study was to examine trends in prevalence and predictors of undernutrition (underweight, stunting, and wasting) among children aged 6-59 months in SCS. I examined the trend of undernutrition from 2007 to 2012. Further, I examined predictors of undernutrition at the individual child, household, and society level. Then, I examined predictors of undernutrition when all three levels of exposure are considered simultaneously. Finally, I identified significant predictors of undernutrition. In this chapter, I interpret and discuss the findings of this study, compare them with findings from existing literature, and make conclusions. I conclude with recommendations from the study and implications for social change.

Summary of Results

Results of this study showed that from 2007 to 2012, there was a declining trend in the prevalence in stunting ($R^2 = 0.73$; $p < 0.05$), a declining trend in underweight ($R^2 = 0.23$; $p = 0.339$) and an increasing trend in wasting ($R^2 = 0.28$; $p = 0.285$). However, the trends in underweight and wasting were not statistically significant. The results further showed that diarrhea, malaria, and gender were significant predictors of underweight at the child level, while household diet diversity and meal frequency were the significant predictors of underweight at the household level. Regarding stunting, results showed that ARIs, diarrhea, and malaria were significant predictors at the child level while meal frequency and access to water were the significant predictors at the household level. ARI, diarrhea, and malaria were child level factors that significantly predicted wasting while diet diversity, meal frequency, and access to sanitation were household factors that significantly predicted wasting. Geographical region and livelihood system were significant predictors of underweight and wasting at the society level. When all levels of exposure (child, household, and society level) were considered simultaneously, diarrhea, child gender, diet diversity, meal frequency, region, and livelihood system were found to be the statistically significant predictors of underweight while stunting was significantly predicted by child gender, meal frequency, region, and livelihood system. Wasting was significantly predicted by diarrhea, malaria, diet diversity, region, and livelihood system when all levels of exposure were considered simultaneously. Of all the significant predictors of undernutrition, only ARI, access to safe water, and access to sanitation had statistically significant trends (declining trend for ARI: R^2=0.82; $p < 0.05$); increasing for water and sanitation (R^2=0.97; $p<0.001$ and R^2=0.67; $p<0.05$ respectively).

Interpretation and Discussion of the Key Findings

Trends in Prevalence of Underweight

A plot of underweight against time showed a decline in prevalence with a sharp drop in 2009 and a sharp peak in 2011. While there could have been a decline in the prevalence of underweight in 2009, the sharp drop is likely due to gaps in the data. However, the increase in prevalence in 2011 could be linked to the 2011 famine in Somalia that pushed the prevalence of GAM to exceed 30% in most parts of SCS (Hillbruner & Moloney, 2012). As such, an increase in the prevalence of underweight in 2011 can be explained by the high level of acute wasting malnutrition in 2011 because underweight is a composite indicator that combines wasting and stunting. Overall, between 2007 and 2012, declining trends in underweight were observed among children over 24 months old, but it was not statistically significant. However, Stevens et al. (2012) observed that between 1985 and 2011, there was a deterioration in underweight with the situation getting worse in countries like Somalia. This divergence in findings could be because this study only covered SCS.

Trends in Prevalence of Stunting

Stunting showed a declining trend from 2007 until 2012 (R^2 = 0.728, $p < 0.05$). This trend was observable among pastoral, urban, riverine, and IDP populations, but it was not observable among agropastoralists (R^2 = 0.021). Overall, the prevalence of stunting among agropastoralists (28.9%) was only second to the highest prevalence among riverine (31%), such that the absence of a clear trend among agropastoralists should be a concern for further investigation. Nutrition programming in Somalia does not typically focus on stunting, but rather on addressing wasting and underweight that have greater consequences for child survival. However, interventions to address stunting should be equally considered because of the long-term effects that it has on child growth and the likelihood of its coexistence with wasting and underweight. Assessing comorbidity and correlates of wasting and stunting among children in Somalia Kinyoki, Kandala et al. (2016) established spatial correlations between stunting and underweight (0.73) and wasting and stunting (0.3) recommending programs that address common risk factors and that target areas with a high co-distribution.

Trends in the Prevalence of Wasting

Wasting, overall, showed an increasing trend (R^2 = 0.28) that was persistently above the 15% emergency threshold with a peak in 2011 at 22.5%. However, this trend was not statistically significant (*p* = 0.285). Among the different livelihoods, the increasing trend in wasting was observed among pastoral, riverine, and IDP populations, but it was also not statistically significant. Wasting is a result of a severe shortage of food or severe infection resulting from harsh conditions like drought and armed conflict that severely limit access to food and access to services. Such harsh conditions characterized most parts of SCS over the period covered by this study leading to the declaration of famine in 2011. Pastoralist populations are likely to be most affected by drought conditions that are exacerbated by conflict, while IDPs in Somalia are a product of drought and conflict. As such, the increasing trend of wasting among pastoralists and IDPs could be explained as an effect of drought and conflict on household dynamics that directly influence children's nutrition. While wasting increases the risk of child mortality with fatalities capable of reaching 50% in cases of SAM, with proper treatment, fatalities can be significantly reduced (WHO, 2017c) and catch up growth can be achieved for children who are younger than 11 months (Richard et al., 2012). The WHO (2017c) recommended the implementation of community-based management of CMAM programs to effectively manage child wasting. Management of SAM is one of the 10 evidence-based nutrition interventions that have been identified to potentially reduce U5M by 15% (Bhutta et al., 2013).

Any level of underweight, stunting, and wasting is associated with an increased risk of child mortality (Olofin et al., 2013). During its 3-year NDP (2017 -2019), the Federal Government of Somalia targeted to reduce underweight from 13.4% to 9%, stunting from 12% to less than 7%, and wasting to under 10%. This study points to a need for programs that address risk factors for all three undernutrition conditions as presented in the next section. A more updated trend analysis would generate information that can be used to inform nutrition program goals and targets for the new NDP.

Predictors of Underweight, Stunting, and Wasting

Infections result into appetite loss, poor absorption of nutrients and diversion of nutrients to fighting disease and repairing the body tissue which predisposes children to be underweight, stunted or wasted (Jones, Thitiri, Ngari, & Berkley, 2014). However, children that are undernourished are more vulnerable to diseases and infections which perpetuates the vicious cycle of malnutrition (Jones, Thitiri, Ngari, & Berkley, 2014). Results of the study showed that diarrhea was a significant immediate cause of underweight, stunting, and wasting in SCS. The chances of being underweight, stunted, or wasted were increased by 26 -41%, 12-24%, and 22-39% respectively among children that were reported to have had diarrhea within two weeks of the survey. These results are consistent with results from a study in Somalia, which found that wasting and stunting were significantly associated with fever and diarrhea (Kinyoki et al., 2015). The results also support findings from elsewhere that have established a negative association between diarrhea and underweight, stunting and wasting (Aheto et al., 2015; Asfaw *et al.*, 2015; Fekadu et al., 2015; Fink, Günther &Hill, 2011**;** Tufa et al., 2018**)**. However, Guerrant, Schorling, and McAuliffe (1992) demonstrated that diarrhea was both a cause and effect of undernutrition which makes diarrhea a complex infection with far-reaching consequences on morbidity and mortality children.

Results of this study also showed that malaria or fever increased the odds of being underweight, stunted, or wasted by 4-17%, 2-13%, and 4-18% respectively. Evidence on the association between malaria and undernutrition is mixed with different studies examining opposite causal directions. Debashish et al. (2018) concluded that the effect of malaria and undernutrition is not conclusive but point out that chronic undernutrition was in most studies associated with severe malaria. Ning, Kimbi, Nkuo-Akenji, Sumbele, and Bopda (2015) also established that among children that were underweight and stunted, the prevalence of malaria parasites was higher than in their normal counterparts. Keusch et al. (2014) have sought to understand the effect of undernutrition on malaria showing the bidirectional relationship between infections and malnutrition. Despite the inclusive evidence on the effect of malaria on undernutrition, results from this study show that malaria is a factor that contributes to increased risk of underweight in SCS.

While ARI was significantly associated with underweight, stunting, and wasting in bivariate analysis, the association with underweight and stunting was lost in multivariate analysis. ARI only remained a significant predictor of wasting. These results are partially consistent with findings by Kinyoki, et al. (2016) where ARI was found to have a significant relationship with all the three undernutrition conditions in a study conducted in Somalia. The difference in the results could be related to the scope of the studies where Kinyoki *et al.* (2016) covered the whole of Somalia, yet this study only covers the SCS. While this study examined ARI as a predictor of undernutrition, several studies show undernutrition as a risk factor for ARI, which points to the bidirectional relationship between infections and undernutrition. For instance, Cox et al. (2017) found that malnutrition was a risk factor for ARI (underweight: OR 1.98, 95% CI 1.12- 3.50, P = .02) and wasting: OR 2.62, 95% CI 1.17- 5.89, P = .02.) and Leung et al. (2015) found that severe acute malnutrition (severe wasting) was a significant predictor of concurrent presence of pneumonia and diarrhea. Guerrant et al. (1992) also demonstrated a similar relationship between diarrhea and undernutrition.

Measles alone or in combination with different forms of undernutrition has been shown to increase child mortality (Mahmud, Alam, & Metcalf, 2019; Salama et al., 2001). As such public health responses like as mass measles vaccination campaigns are recommended for refugee camps, famine-affected and displaced population populations, where large populations gather in central locations to receive services (Toole, Steketee, Waldman, & Nieburg, 1989). Despite findings regarding associations between measles infections and undernutrition, this study did not find a significant association with any of the three undernutrition outcomes similar to what was established by Kinyoki et al. (2015).

Overall, this study shows that diarrhea and malaria are significant predictors of all undernutrition conditions among Somali children while pneumonia was a significant predictor of wasting. Other research has shown that malnutrition increases occurrence, severity, and fatality outcomes from diarrhea, malaria, and ARI. These findings call for intensive and large-scale interventions to address risk factors for diarrhea, malaria and

ARI and effective management of severe acute malnutrition, which increases the risk and fatality for malnourished children with these infections.

Gender

Child gender was a significant predictor of underweight, stunting, and wasting. The odds of being underweight, stunted, or wasted were reduced by 17 -24%, 18-24% and 20-28% among female children. Several studies (Asfaw et al., 2015; Beyene, Ahiadeke, & Hamid, 2017; Meshram et al., 2012) studies have also found that male children had an increased risk of underweight. Kinyoki et al. (2015) and Tufa et al. (2018) found that male children had an increased risk of wasting. Further, other studies (Asfaw *et al.*2015; Kinyoki et al.,2015; Sodha *et al.*, 2011; Wamani, Åstrøm, Peterson, Tumwine, & Tylleskär, 2007) found that boys had an increased risk of stunting when compared to girls. The explanation for increased risk of undernutrition among boys could be more biological than environmental as it is expected that gender biased behaviors in the household would likely favor boys over girls in the context of Somalia.

Age

Age group was a statistically significant predictor of stunting and wasting but not underweight although its association with wasting was lost in multivariate analysis. Children that were older than 24 months were at greater risk of being stunted compared to younger children which is consistent with the notion that the effects of poor feeding are likely to take root after weaning which happens at 24 months. Others have also reported a significant association between an increase in age with stunting and underweight (Aheto et al., 2015; Choudhury et al., 2017; Sodha et al., 2011). Similar findings have been reported by Kinyoki et al. (2015) and Kinyoki et al. (2017) in national coverage studies in Somalia. Sufficient to conclude from the results of this study that age is a factor in malnutrition with older children being more at risk of stunting. Interventions that focus on increasing access to diverse foods and educating caregivers on locally available foods that meet children's diet requirements, feeding frequency, and appropriate hygiene would help to reduce the risk of undernutrition in children that are above 24 months old.

Proximal Predictors of Undernutrition

In this study, household diet diversity was used to assess access to food as an underlying cause of undernutrition. Results showed that household diet diversity was a significant underlying cause of underweight and wasting where adding one food group to a household's diet reduced the likelihood of children being underweight by 3-12% and the likelihood of wasting by 2-6%. Household diet diversity was also a significant predictor of stunting in bivariate analysis, but this association was lost in multivariate analysis. This study postulates that household diet diversity determines the foods that are available for children to consume, which, influences children's diet intake that directly affects children's nutrition status. The significance of diverse diets has been documented in other studies. For instance, Chandrasekhar et al. (2017) and Menon et al. (2015) found that children that consumed more diverse diets were less likely to be underweight or wasted or stunted. Saaka and Osman (2013) also found that low household diet diversity was significantly associated with chronic malnutrition (stunting) but not wasting while Motbainor, Worku, and Kumie (2015) found that food diversity was a significant predictor of stunting. However, McDonald et al. (2015) did not find an association between diet diversity and any anthropometric outcomes and argued that factors beyond diet diversity were important in driving undernutrition. While other factors like knowledge of appropriate complementary feeding and intrafamily food distribution may affect the diversity of the foods consumed by children and therefore the potential effect on undernutrition, findings of this study are plausible because the availability of diverse foods in the household increases chances of children consuming foods that offer protection from undernutrition.

This study did not examine the relationship between food security and nutrition, but existing literature points to pathways of association that are related to the findings of this study. Chandrasekhar et al. (2017) and Ali et al. (2013) have shown that children in food-insecure households are likely to have limited diet diversity and more likely to be stunted, underweight or wasted. In 2011 more than 20% of the populations in SCS faced extreme food shortages surpassing the threshold for famine classification (Hillbruner & Moloney, 2012). Results of this study show that the prevalence of underweight and wasting (24.9% and 22.5% respectively) was highest in 2011, which could explain the observed association between household diet diversity and underweight and wasting. While existing evidence on the relationship between food security and undernutrition is mixed with some arguing for the existence of an association and others arguing for non-existence of an association, findings from this study provide a basis for investigating the potential association between food security and undernutrition in SCS.

Feeding practices

This study examined the association between undernutrition outcomes and two indicators of infant and young child feeding: exclusive breastfeeding and minimum meal frequency. Minimum dietary diversity could have been used in this study as another indicator for infant and young child feeding, but nutrition surveys did not consistently collect data on foods consumed by children rather foods consumed in the household. Results of this study showed that exclusive breastfeeding was only significant in the bivariate analysis for underweight but lost its significance in multivariate analysis while it was not significantly associated with stunting or wasting. This finding is contrary to what was expected given the protective effect of exclusive breastfeeding on child undernutrition that has been reported by others (Egata et al., 2014; Fekadu et al., 2015; Kuchenbecker et al., 2015).

However, the results of this study still point to the importance of exclusive breastfeeding in protecting children from undernutrition. The prevalence of underweight among children that were exclusively breastfed was 17.4% compared to 21.8% among children that were not exclusively breastfed, and there was a statistically significant association between exclusive breastfeeding and underweight, $\chi^2(1) = 4.046$, $p = .044$. Stunting was 20.8% among exclusively breastfed children compared to 25% among children that were not breastfed, but this difference was not statistically significant while wasting was also lower among children that were exclusively breastfed (13.4% vs. 15.8%) compared to children that were not exclusively breastfed, but the association was not statistically significant. Overall, promotion of breastfeeding is considered to be one of the 10 interventions that if implemented at 90% coverage show 20·3% (range 10·2–28·9) reduction in stunting and a 61·4% (35·7–72) reduction in severe wasting (Bhutta et al., 2013).

Results of this study showed that minimum feeding frequency decreased the chances of children being underweight by 9-23% and the chance of being stunted by 32-47%, but it was not a significant predictor of wasting. Similarly, Motbainor, Worku, and Kumie (2015) found that increasing the number of meals that a child ate increased their weight while Marriott et al. (2012) who found that feeding frequency was significantly associated with underweight but not stunting. The frequency of feeding children in a household could be influenced by food availability and the care giver's knowledge of feeding requirements for infant and young children. As such, the 2011 famine in Somalia that significantly reduced access to food, especially in most regions of SCS could be the underlying cause of the high levels of underweight and wasting in 2011.

Water and Sanitation

Access to safe water, adequate sanitation facilities, and good hygiene practices are central to the survival and development of children. Water, Sanitation and Hygiene play a critical role in the nutrition status of children through three known pathways to undernutrition: diarrhea/diarrheal diseases, intestinal parasite infections and environmental enteropathy especially among children (WHO, 2015a). Poor water, sanitation, and hygiene increase the chances of diarrheal diseases which reduces effective absorption of nutrients and in the long run increases the risk of stunting, underweight and wasting (Fink et al., 2011; Wolf et al., 2014). Intestinal parasitic infections acquired from poor sanitation cause poor absorption of nutrients, loss of appetite and increased loss of blood and in the long run harm the normal process of growth in children (Stephenson, Latham, & Ottesen, 2002). Environmental enteropathy leads to inflammation of the gut that results in malabsorption of nutrients that in turn leads to stunting in children (Harper, Mutasa, Prendergast, Humphrey, & Manges, 2018; Humphrey, 2009). This study specifically examined the relationship between access to safe water and sanitation facilities with undernutrition.

Results of this study showed that access to safe water was a significant predictor of stunting and wasting where increased access reduced the chances of stunting by 4-24% ($p<0.5$) and wasting by 5-17% ($p<0.001$). In the bivariate analysis, access to water had a significant relationship with underweight, but the relationship was lost in the multivariate analysis. However, the results show that the prevalence of underweight among households that had access to protected water sources (20.6%) was lower than households that did not have access to protected water sources (24.5%), but the difference was not statistically significant. Results further show that increased access to sanitation facilities reduced chances of wasting by 7% ($p<0.05$). Access to sanitation also had a significant association with underweight and stunting, but the association was lost in multivariate analysis. These results are consistent with what has been established in other studies. For instance, Fink, Günther, and Hill, (2011) in a study covering 70 low and middle-income countries established that improved assess to water and improved access to sanitation lowered the risk of diarrhea and the risk of mild or severe stunting among children under the age of 5 years. Rah et al. (2015a) and found that in households with access to a toilet facility, children aged 0–23 month had 16–39% reduced odds of stunting when compared with children in households with open defecation. Spears, Ghosh, and Cumming (2013) established that open defecation in India was associated with an increase in both stunting and severe stunting.

Comparing the trends of access to water and sanitation, results showed that both were increasing, but the trend was stronger for access to water than access to sanitation facilities ($R^2 = 0.97$ vs. $R^2 = 0.67$). It is thus imperative to continue investing in community-wide interventions to increase the use of sanitation facilities as progress is made to the eradication of open defecation. However, access to safe water and sanitation facilities may not be sufficient to offer exhaustive protection from diarrhea/diarrheal diseases, intestinal parasite infections, and environmental enteropathy. Other water and hygiene practices such as treating and proper storage of drinking water and washing hands with soap before feeding children or touching food and washing hands after using the toilet are important factors in the pathways to undernutrition (Rah *et al.*, (2015b); Sodha *et al.*, (2011). However, these factors were not assessed in this study yet they could have additive or synergistic effects on child linear growth. Further research on the role of treatment and storage of water and handwashing practices on undernutrition in SCS may shade more light on interventions to break the cycle of undernutrition.

Gender in Household Decision-Making

Gender of the household head was found to be associated only with stunting, where children in households that were headed by women have 9% lower chances of being stunted compared to those in households headed by men. However, when gender was added to the multivariate model, it lost its significance. The absence of an association between gender and wasting and the association between gender and underweight could be due to the short time that it takes for the two undernutrition conditions to develop such that the influence of who controls resources in the household is insignificant in the short term. Given that stunting is a result of sustained poor feeding, it is likely to be reduced in households where women control resources and decision making according to the results of this study.

In a systematic review of women empowerment in South Asia, Cunningham et al. (2015) reported that women's empowerment in the household in terms of control of resources, social support, and workload were associated with child nutrition though its influence could vary with context, child age, and maternal characteristics. The gender of the head of household could influence child nutrition according to their responsibilities for child feeding and feeding, where knowledge of appropriate feeding practices and the amount of time they have to allocate to child feeding would be important factors (Nankumbi & Muliira, 2015; Kabir et al., 2017). In addition, the gender of the household head would determine whether the child caregiver can make decisions and allocate resources for food that is consumed in the household and other decisions like health care for sick children.

The role of gender equality on reducing stunting has been argued severally. Smith & Haddad (2015) established an inverse relationship between the Gender Inequality Index and stunting and wasting in a study covering 96 countries. Smith and Haddad (2015) argued that improving women's education, gender equality, and national food availability could result in reducing national stunting rates in the post MDG era. Further, Kerr et al (2016) argued that improving access to food quantity and quality in the household would not be enough to improve nutrition if there were gender biases that influenced child care, resource control, and decision making. Further Alemayehu et al. (2015) found that children whose mothers could make final decisions were less likely to be underweight than those whose fathers were the decision makers (AOR, 0.33; 95% CI, 0.15–0.74). These arguments and the results of this study point to the likely benefits for child nutrition if gender inequality in Somalia is addressed. The Gender Inequality Index for Somalia is 0.776 (UNDP, 2015).

Access to health facilities was not found to be a significant predictor for either underweight, stunting, or wasting. However, some advantages were observed between different options of health care when compared to not having any health care at all. It appears that these advantages were not strong enough to support an association between access to health care and undernutrition.

Distal Predictors of Undernutrition

SCS is divided into 10 administrative regions. The regions have variations in economic status, governance and political dynamics, livelihood systems, and the urban vs. rural population distribution that may variably influence the nutrition status of children. Results of this study show that geographical region was a significant predictor of underweight, wasting, and stunting. When compared to Banadir the region that hosts the government capital and offers better social services; children in all the regions were more likely to be underweight especially those in Bay (67%), Gedo (59%) and Bakool

(51%). However, when livelihood system was controlled, the significance of region as a predictor of underweight was lost in all regions except Bay. Compared to Banadir, the odds of stunting were lower in all regions except M. Juba, Lower Shabelle, and Bay while the odds of wasting were higher in all the regions especially Gedo (2.6 times), Bay (2.09 times) and M.Shabelle (2.07 times). The higher odds of wasting and underweight are linked to the heightened level of food insecurity and conflict that were prevalent over the period covered by this study, especially in 2011. Drought and armed conflict severely constrained food production, as well as access markets and basic services but Majid and McDowell (2012), argued that drought conditions exacerbated effects of the already existing fundamental clan-based social and political disadvantages in the most affected populations. The association between geographical region or area of residence with undernutrition has been found in other studies. Kismul, Acharya, Mapatano, and Hatløy (2017) in their study on determinants of childhood stunting in the Democratic Republic of Congo, found that region was associated with stunting while Motbainor, Worku, and Kumie (2015) in Ethiopia also found that residential area was a significant predictor of child undernutrition. Results for this study show that the association between region and child undernutrition is displayed in subnational disparities that call for targeted interventions to address immediate and underlying factors that influence the conditions in which children are born and raised.

Livelihood System

Livelihood system was found to be a significant predictor of all three conditions of undernutrition. This study used five livelihood system groupings; pastoral, agro-pastoral, riverine, urban, and IDP as the groups used in undertaking nutrition surveys in Somalia. When using pastoralists as the reference category, the odds of underweight were higher among both the agro-pastoralist and riverine populations but lower among urban and IDP populations though statistical significance was lost among IDPs in multivariate analysis. Similarly, the odds of stunting were higher among all the livelihoods except the urban population and remained statistically significant in the multivariate analysis except IDP. However, when compared to pastoralists, the odds of wasting were lower in all the regions.

Overall, study results showed higher chances of child undernutrition among agro-pastoral and riverine populations, which could be explained by social, economic, and political position in Somalia. Both agro-pastoral and riverine populations practice rain-fed agriculture, keep few livestock, with the poorer groups laboring in farms or urban areas to access food or income. Socially they consist of minority clans that suffer dominance from larger clans with lootings and forced displacements that leave them poorer and dependent on aid (Majid and McDowell, 2012). As a result, drought and conflict in areas occupied by these population groups have a severe effect on access to food, income and basic services which all undermine their ability meet children's health and nutrition needs. When the livelihood of agropastoralists and riverine populations are disrupted by drought, conflict, and other social-political factors, food insecurity in

Somalia increases because they provide Somalia's food basket. The macro effect is increased undernutrition, especially among children and women. As such, overcoming social and political marginalization of the populations in the agropastoral and riverine areas of SCS to harness their food production capability could reduce vulnerability to food insecurity, redistribute wealth and tackle disparities in child nutrition and other human development indicators.

Armed Conflict

Conflict limits the ability of households to produce and or access food; it limits access to basic services including health and causes displacement that may interrupt infant and young child feeding practices (Tranchant et al., 2014). These limitations and disruptions undermine children's nutrition status and may increase mortality and morbidity. Results of this study, however, showed that conflict was not a significant predictor of any of the undernutrition outcomes, contrary to what was expected and what was established by Kinyoki et al. (2017). The possible explanation of this inconsistency could be the difference in the variable that was used in this study. While Kinyoki et al. (2017) grouped event types into different classes for the analysis, in this study, I used the average number of reported conflict events at the district level as an estimated number of events for each observation that lived in the respective district. This was based on the assumption that conflicts in a geographical area (district) would cause limitations and disruptions for the population living in that geographical area. In addition, lack of significance of conflict as a predictor of undernutrition could be related to the movement of populations where the children could have been surveyed in locations that were different from where they experienced conflict creating the mismatch observed between nutrition status and conflict situation.

While conflict did not have a direct effect on underweight, stunting or wasting, it was found to be significantly associated with access to sanitation $\chi^2(1) = 208.67$, $p < 0.001$, exclusive breastfeeding $\chi^2(1) = 5.78$, $p < 0.05$, and household diet diversity which were significant predictors of underweight, stunting and wasting. Indeed a similar study on the effect of conflict practices in Ukraine found that mothers that discontinued breastfeeding before 6 months listed stress related to conflict as their primary reason for discontinuation (Summers & Bilukha, 2018).

Maxwell & Fitzpatrick, (2012) and Checchi and Robinson (2013) have argued the role of conflict in the Somalia famine of 2011. While this study did not show a direct link between conflict and undernutrition, results show a plausible pathway of conflict to undernutrition through its effect on feeding practices and household diet diversity. It is thus imperative that all efforts for peace and stabilization of the country are pursued relentlessly.

Limitations of the Study Findings

Data that was used in this study was merged over 60 nutrition surveys, some of which did not collect data on all the variables of interest, while some of the datasets were incomplete. This led to a significant level of missing data. While an analysis of missing data revealed that there was not much of a difference between observations with complete and those without complete data on the variables of interest, final results could have been affected by this limitation. Further, the data used in this study were collected from all children aged 6-59 months in each identified household, which introduced correlations that were accounted for by using the GEE. However, this leads to the exclusion of households that could not be uniquely identified, affecting the sample distribution that may have had an influence on the results. In addition, sampling weights for the different surveys could not be established, which limited the ability to apply complex survey analysis procedures. Results of this study should be interpreted in light of this limitation. This study was a cross-sectional design using data collected over six years in cross-sectional household surveys. The results, therefore, only point to an association between variables and do not claim causality.

Recommendations

Results of this study showed that stunting and underweight were on a decline, but wasting had an increasing trend. The trends also showed disparities in different livelihoods, which point to the relevance of subnational trends to appropriately target interventions. This study only analyzed trends in undernutrition until 2012; an updated trend analysis to see more recent trends and predict patterns for the future is highly recommended. Such information will be useful in developing nutrition goals and targets for Somalia’s NDP for 2020-2022.

Diarrhea and malaria were significant predictors for all the three undernutrition conditions, yet they are preventable and manageable childhood infections. Approaches such as Integrated Community Case Management (iCCM) have demonstrated effectiveness in the management of diarrhea, pneumonia, malaria, and malnutrition in resource-poor settings where access to facility-based health care is limited (Abegunde et al., 2016; Brenner et al., 2017; Rivera et al., 2017;). According to UNICEF (2012), iCCM is a strategy that brings treatment closer to home with demonstrated evidence in achieving high treatment coverage and reducing case fatality. The WHO (2019) underscored the fact that iCCM is an equity-focused strategy that extends public health services to underserved populations. In Somalia, the government, in partnership with several humanitarian and development partners, has started implementing iCCM, although it is project based and geographical coverage is still limited. More significant gains could be realized by adopting and resourcing a national iCCM policy, strategy, and program. Such a program would provide a framework for all health sector actors and donors to harmonize efforts towards a common goal and targets. Further, factoring implementation research into iCCM programs would help to understand better the dynamics and system-wide factors that affect the effective translation of this evidence-based approach into practice in the Somalia context.

IYCF practices in Somalia remain suboptimal, yet the results of this study show their significant association with undernutrition. Based on the results of this study, it is highly recommended to continue promoting IYCF practices with increased attention exclusive breastfeeding, minimum diet requirements for young children, and appropriate feeding frequency for different ages. Such activities should not be simple adoptions of strategies that have been successful elsewhere, but through both observational and experimental research seek to understand cultural-social norms, motivations, and capacities that influence behavior. Further, the application of behavior change theory that is contextualized in program development and implementation could lead to changes that programs have sought with much success.

Access to diverse food at all times allows care givers to meet their children's nutrition needs. However, Somalia faces chronic food shortages that have severally deteriorated to famine or near famine situations. There is, therefore, a need for strategies and investments to optimize production in the food baskets of Somalia while safeguarding them from the brunt effect of climate change. Restoration of water harvesting and storage infrastructure that is dilapidated, investment in irrigation infrastructure and adoption of climate-smart technologies could secure food production in the agro-pastoral and riverine areas. Such investments should also extend to livestock farming that also suffers the brunt effect of climate change. The World Bank and FAO have identified and recommend policy reforms and investment options for rebuilding the agricultural sector Somalia (FAO & World Bank, 2018). Such investments will not only contribute to improving food production and national income but also address underlying inequalities that drive social economic disparities in undernutrition as seen in this study.

As demonstrated in this study, water and sanitation are significant predictors of child undernutrition in South Central Somalia. More program investments in improving access to safe water and sanitation, along with culturally sensitive health promotion could address this important underlying cause of undernutrition. Other countries like Bangladesh and Nepal have recorded significant reductions in undernutrition that has been closely linked to reduction in open defecation (Headey et al., 2015; Headey & Hoddinott, 2015).

Implications for Positive Social Change

The UNICEF conceptual framework of determinants of undernutrition provides a causal chain for undernutrition based on strong evidence generated in different contexts. This study applies the framework in SCS and generates information on predictors that have a significant relationship with undernutrition in the local context. The study findings and related recommendations should be adapted into nutrition programs, policie, and investments to improve the nutrition status of children in SCS. At the family level, findings of this study point to important predictors of childhood undernutrition in SCS that can be addressed through nutrition-specific interventions. The study findings also point to important policy level actions that prevent undernutrition among children in Somalia. Specifically, this study recommends a national adoption of integrated community case management of childhood illness as a key strategy to bring equitable coverage of public health services in treating diarrhea and malaria. The study also recommends investments in Agriculture to improve access to food coupled with context appropriate health promotion on infant and young child feeding. Implementation of these recommendations will address the main predictors of undernutrition in SCS.

This study also identifies and recommends implementation research that will seek to understand further the contextual feasibility of implementing proven solutions in the context of Somalia. Implementation research would generate information on effective solutions as well as the social context of malnutrition that has to be put into consideration when developing nutrition programs and choosing strategies of implementation in different contexts. Implementing solutions that are tailored to the local context and through system-wide approaches will result in positive changes for all children in Somalia.

Conclusions

This study finds that underweight and stunting have declining trends, but wasting has an increasing trend. However, the underweight trend was weak and only observable among children above 24 months old and among pastoralists and urban populations while the trend in stunting was only observable among pastoral, urban, riverine and IDP populations. Wasting had an increasing trend among pastoral, riverine, and IDP populations, a decreasing trend among urban populations while no trend was observed among the agropastoralists. However, an updated trend analysis to inform current programing and goal setting in the upcoming NDP is highly recommended.

Results from this study show that when the causal chain of undernutrition is considered, underweight is significantly predicted by diarrhea/diarrheal diseases, child gender, diet diversity, child feeding frequency, region, and livelihood system. Child gender, feeding frequency, region, and livelihood system were the significant predictors of stunting while wasting was significantly predicted by diarrhea, malaria, diet diversity, region, and livelihood system. Actions such as implementation of a national iCCM strategy; optimizing agricultural production in the food basket of Somalia; promotion of contextually proven strategies for increasing uptake of infant and young child feeding practices; and continued focus on improving water and sanitation are recommended for reducing child undernutrition in Somalia.

References

Abate, K. H., & Belachew, T. (2017). Care and not wealth is a predictor of wasting and stunting of 'The Coffee Kids' of Jimma Zone, Southwest Ethiopia. *Nutrition and Health*, *23*(3), 193-202. doi.org/10.1177/0260106017706253

Abegunde, D., Orobaton, N., Bassi, A., Oguntunde, O., Bamidele, M., Abdulkrim, M., & Nwizugbe, E. (2016). The Impact of Integrated Community Case Management of Childhood Diseases Interventions to Prevent Malaria Fever in Children Less than Five Years Old in Bauchi State of Nigeria. *PLOS One*, *11*(2), 1–13. doi.org/10.1371/journal.pone.0148586

Aheto, J. M. K., Keegan, T. J., Taylor, B. M., & Digg, P. J. (2015). Childhood Malnutrition and Its Determinants among Under-Five Children in Ghana. *Paediatrics and Perinatal Epidemiology*, *26*(6), 552–561. doi.org/10.1111/ppe.12222

Akombi, B., Agho, K., Hall, J., Wali, N., Renzaho, A., & Merom, D. (2017). Stunting, Wasting and Underweight in Sub-Saharan Africa: A Systematic Review. *International Journal of Environmental Research and Public Health*, *14*(8), 863. doi.org/10.3390/ijerph14080863

Alemayehu, M., Tinsae, F., Haileslassie, K., Seid, O., Gebregziabher, G., & Yebyo, H. (2015). Undernutrition status and associated factors in under-5 children, in Tigray, Northern Ethiopia. *Nutrition*, *31*(7–8), 964–970. doi.org/10.1016/j.nut.2015.01.013

Alesina, A., Ozler, S., Roubini, N., & Swagel, P. (1996). *Political instability and economic growth*. *Journal of Economic Growth* 1(2), 189-211 doi.org/10.1007/BF00138862

Asfaw, M., Wondaferash, M., Taha, M., & Dube, L. (2015). Prevalence of undernutrition and associated factors among children aged between six to fifty nine months in Bule Hora district, South Ethiopia. *BMC Public Health*, *15*(14), 2-9. doi.org/10.1186/s12889-015-1370-9

Bell, R., Donkin, A., & Marmot, M. (2013). Tackling Structural and Social Issues to Reduce Inequities in Children ' s O utcomes in Low- to Middle-income Countries Office of Research Discussion Paper. Retrieved from https://www.unicef-irc.org/publications/708/

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

Bhutta, Z. qar A., Das, J. K., Rizvi, A., Gaffey, M. F., Walker, N., Horton, S., … Black, R. E. (2013). Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *Lancet*, *382*, 452–477. doi.org/10.1016/S0140-6736(13)60996-4

Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., De Onis, M., … Uauy, R. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet*, *382*, 427–451. doi.org/10.1016/S0140-6736(13)60937-X

Bove, I., Campoy, C., Uauy, R., Miranda, T., & Cerruti, F. (2014). Trends in Early Growth Indices in the First 24 Months of Life in Uruguay over the Past Decade. *Journal of Health, Population and Nutrition, 32*(4), 600–607. doi:10.1016/j.earlhumdev.2012.04.002

Brcanski, J., Jović-Vraneš, A., Marinković, J., & Favre, D. (2014). Social determinants of malnutrition among Serbian children aged <5years: ethnic and regional disparities. *International Journal of Public Health, 59*(5), 697–706. doi.org/10.1007/s00038-014-0591-5

Brenner, J. L., Barigye, C., Maling, S., Kabakyenga, J., Nettel-Aguirre, A., Buchner, D., … Singhal, N. (2017). Where there is no doctor: Can volunteer community health workers in rural Uganda provide integrated community case management? *African Health Sciences, 17*(1), 237–246. doi.org/10.4314/ahs.v17i1.29

Bronfenbrenner, U. (1994). Ecological Model. In *International Encylopedia of Education* (2nd ed., pp. 37–43). Retrieved from http://www.psy.cmu.edu/~siegler/35bronfebrenner94.pdf

Brown, K., Henretty, N., Chary, A., Webb, M. F., Wehr, H., Moore, J., … Rohloff, P. (2016). Mixed-methods study identifies key strategies for improving infant and young child feeding practices in a highly stunted rural indigenous population in Guatemala. *Maternal and Child Nutrition*, *12*(2), 262–277. doi.org/10.1111/mcn.12141

Chandrasekhar, S., Aguayo, V. M., Krishna, V., & Nair, R. (2017). Household food insecurity and children’s dietary diversity and nutrition in India. Evidence from the comprehensive nutrition survey in Maharashtra. *Maternal and Child Nutrition*, *13*, Suppl 2, 1–8. doi.org/10.1111/mcn.12447

Checchi, F., & Robinson, W. C. (2013). Mortality among populations of southern and central Somalia affected by severe food insecurity and famine during 2010-2012, , 1–87.Retrieved from Food Security and Analysis Unite of Somalia website: http://www.fsnau.org/in-focus/study-report-mortality-among-populations-southern-and-central-somalia-affected-severe-food-

Chege, P. M., Ndungu, Z. W., & Gitonga, B. M. (2016). Food security and nutritional status of children under-five in households affected by HIV and AIDS in Kiandutu informal settlement, Kiambu County, Kenya. *Journal of Health, Population, and Nutrition*, *35*(1), 21. doi.org/10.1186/s41043-016-0058-9

Choudhury, N., Raihan, M. J., Sultana, S., Mahmud, Z., Farzana, F. D., Haque, M. A., … Ahmed, T. (2017). Determinants of age-specific undernutrition in children aged less than 2 years—the Bangladesh context. *Maternal and Child Nutrition*, *13*(3), 1–16. doi.org/10.1111/mcn.12362

Coates, J., Swindale, A., & Bilinsky, P. (2007). Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide. Version 3 (1-34). Retrieved from http://www.fao.org/fileadmin/user_upload/eufao-fsi4dm/doc-training/hfias.pdfCox, M., Rose, L., Kalua, K., de Wildt, G., Bailey, R., & Hart, J. (2017). The prevalence and risk factors for acute respiratory infections in children aged 0-59 months in rural Malawi: A cross-sectional study. *Influenza and Other Respiratory Viruses*, *11*(6), 489–496. doi.org/10.1111/irv.12481

Creswell, J. w. (2009). The Selection of a Research Design. In V.Knight, S. Connelly, L. Habib, S.K. Quesenberry, M.P. Scott (Eds), *Research Design:Qualit*ative, Quantitative and Mixed Methods Approaches (3rd Ed, pp 3- 21). California: SAGE Publications, Inc.

Cunningham, K., Ploubidis, G. B., Menon, P., Ruel, M., Kadiyala, S., Uauy, R., & Ferguson, E. (2015). Women's empowerment in agriculture and child nutritional status in rural Nepal. *Public Health Nutrition*, *18*(17), 3134–3145. doi.org/10.1017/S1368980015000683

de Onis, M., Blössner, M., & Borghi, E. (2011). Prevalence and trends of stunting among pre-school children, 1990–2020. *Public Health Nutrition*, *15*, 141–148. doi.org/doi:10.1017/S1368980011001315

Debashish, D., Philippe, G., Kasia, S., Rashid, M., Grais, R., & Emelda, O. (2018). Complex and vicious interactions between malaria and malnutrition: a systematic review. *BMC Medicine*, *16*(186), 1–14. doi.org/10.1186/s12916-018-1177-5

Dong, C., Ge, P., Ren, X., Wang, J., Fan, H., Yan, X., & Yin, S. an. (2013). Prospective Study on the Effectiveness of Complementary Food Supplements on Improving Status of Elder Infants and Young Children in the Areas Affected by Wenchuan Earthquake. *PLOS One*, *8*(9), 1–7. doi.org/10.1371/journal.pone.0072711

Egata, G., Berhane, Y., Worku, A., Collins, S., Dent, N., Binns, P., … Tamim, H. (2014). Predictors of acute undernutrition among children aged 6 to 36 months in east rural Ethiopia: a community based nested case - control study. *BMC Pediatrics*, *14*(1), 91. doi.org/10.1186/1471-2431-14-91

Food and Agricultural Organization (FAO). (2006). *Food security*. *Policy Brief*. doi.org/10.1016/j.jneb.2010.12.007

Food and Agricultural Organization (FAO) & World Bank. (2018). *Rebuilding Resilient and Sustainable Agriculture in Somalia* (Vol. I). Retrieved from http://documents.worldbank.org/curated/en/781281522164647812/pdf/124651-REVISED-Somalia-CEM-Agriculture-Report-Main-Report-Revised-July-2018.pdf

Federal Government of Somalia. (2017). The Somalia National Development Plan (SNDP) – Towards Recovery, Democracy and Prosperity. Retrieved from http://mopic.gov.so/wp-content/uploads/2016/11/SOMALIA-NATIONAL-DEVELOPMENT-PLAN-2017-2019.pdf.

Fekadu, Y., Mesfin, A., Haile, D., & Stoecker, B. J. (2015). Factors associated with nutritional status of infants and young children in Somali Region, Ethiopia: a cross-sectional study. *BMC Public Health*, *15*:846, 2 -9. doi.org/10.1186/s12889-015-2190-7

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

Galler, J. R., Bryce, C. P., Zichlin, M. L., Fitzmaurice, G., Eaglesfield, G. D., & Waber, D. P. (2012). Infant Malnutrition Is Associated with Persisting Attention Deficits in Middle Adulthood. *Journal of Nutrition*, *142*(4), 788–794. doi.org/10.3945/jn.111.145441

Galler, Janina R., Bryce, C. P., Waber, D. P., Hock, R. S., Harrison, R., Eaglesfield, G.

D., & Fitzmaurice, G. (2012). Infant malnutrition predicts conduct problems in adolescents. *Nutritional Neuroscience*, *15*(4), 186–192. doi.org/10.1179/1476830512Y.0000000012

Gautam, K. P., Adhikari, M., Khatri, R. B., & Devkota, M. D. (2016). Determinants of infant and young child feeding practices in Rupandehi , Nepal. *BMC Research Notes*, 1–7. doi.org/10.1186/s13104-016-1956-z

Gillespie, S., Haddad, L., Mannar, V., Menon, P., & Nisbett, N. (2013). The politics of reducing malnutrition: Building commitment and accelerating progress. *Lancet*, *382*(9891), 552–569. doi.org/10.1016/S0140-6736(13)60842-9

Grillo, L. P., Gigante, D. P., Horta, B. L., & de Barros, F. C. F. (2016). Childhood stunting and the metabolic syndrome components in young adults from a Brazilian birth cohort study. *European Journal of Clinical Nutrition*, *70*(5), 548–553. doi.org/10.1038/ejcn.2015.220

Guerrant, R. L., Schorling, J. B., & Jay F. McAuliffe, M. A. D. S. (1992). Diarrhea as a Cause and an Effect of Malnutrition: Diarrhea Prevents Catch-up Growth and Malnutrition Increases Diarrhea Frequency and Duration. *The American Journal of Tropical Medicine and Hygiene*, *Volume 47*(Isssue 1), 28–35. doi.org/10.4269/ajtmh.1992.47.28

Hanieh, S., Ha, T. T., Simpson, J. A., Thuy, T. T., Khuong, N. C., Thoang, D. D., … Biggs, B. A. (2015). Exclusive breast feeding in early infancy reduces the risk of inpatient admission for diarrhea and suspected pneumonia in rural Vietnam: A prospective cohort study Global health. *BMC Public Health*, *15*(1), 1–11.

doi.org/10.1186/s12889-015-2431-9

Hanley, J. A., Negassa, A., Edwardes, M. D. d. B., & Forrester, J. E. (2003). Statistical analysis of correlated data using generalized estimating equations: An orientation. *American Journal of Epidemiology*, *157*(4), 364–375. doi.org/10.1093/aje/kwf215

Hare, B. O., Makuta, I., Chiwaula, L., & Bar-zeev, N. (2013). Income and child mortality in developing countries : a systematic review and meta-analysis, *106*(10), 408–414. doi.org/10.1177/0141076813489680

Harper, K. M., Mutasa, M., Prendergast, A. J., Humphrey, J., & Manges, A. R. (2018). Environmental enteric dysfunction pathways and child stunting: A systematic review. *PLoS Neglected Tropical Diseases*, *12*(1), 1–23. doi.org/10.1371/journal.pntd.0006205

Headey, D., Ali, D., Tesfaye, R., Dereje, M., & Hoddinott, J. (2015). The Other Asian Enigma : Explaining the Rapid Reduction of Undernutrition in Bangladesh. *World Development*, *66*, 749–761. doi.org/10.1016/j.worlddev.2014.09.022

Headey, D., & Hoddinott, J. (2015). Understanding the rapid reduction of undernutrition in Nepal, 2001-2011. *PLOS One*, *10*(12), 2001–2011. doi.org/10.1371/journal.pone.0145738

Hillbruner, C., & Moloney, G. (2012). When early warning is not enough—Lessons learned from the 2011 Somalia Famine. *Global Food Security*, 1–9. doi.org/10.1016/j.gfs.2012.08.001

Hoddinott, J., Alderman, H., Behrman, J. R., Haddad, L., & Horton, S. (2013). The economic rationale for investing in stunting reduction. *Maternal and Child*

Nutrition, 9(S2).69 - 82 doi.org/10.1111/mcn.12080

Humphrey, J. H. (2009). Child undernutrition, tropical enteropathy, toilets, and handwashing. *Lancet*, *374*, 1032–1035. doi.org/10.1016/S0140-6736(09)60950-8

Imai, K. ., Annim, S. K., Kulkarni, V., & Gaiha, R. (2014). Women's empowerment and Prevalence of Stunted and underweight children in rural India. *World Development*, *62*, 88–105. doi.org/10.1016/j.worlddev.2014.05.001

International Food Policy Research Institute. (2016). Global Nutrition Report 2016: From Promise to Impact: Ending Malnutrition by 2030. Retrieved from https://doi.org/http://dx.doi.org/10.2499/9780896295841

Johnson, S. A. (2017). The Cost of War on Public Health: An exploratory method for understanding the impact of conflict on public health in Sri Lanka. *PLOS One 12*(1), 1–28. doi.org/10.1371/journal.pone.0166674

Jones, A. D., Acharya, Y., & Galway, L. P. (2016). Urbanicity Gradients Are Associated with the Household- and Individual-Level Double Burden of Malnutrition in Sub-Saharan Africa. *Journal of Nutrition*, *146*(6), 1257–1267. doi.org/10.3945/jn.115.226654

Jones, A., Ngure, F. M., Pelto, G., & Young, S. L. (2013). What Are We Assessing When We Measure Food Security? A Compendium and Review of Current Metrics. *Advances in Nutrition*, *4*, 481- 505. doi.org/10.3945/an.113.004119.disciplines

Jones, K., Thitiri, J., Ngari, M., & Berkley, J. A. (2014). Childhood malnutrition: Toward an understanding of infection, inflammation, and antimicrobials. *Food and Nutrition Bulletin*, *35*(2), S64. doi.org/10.1001/jama.2009.1266

Kabir, A., Rose, M., & Maitrot, L. (2017). Factors influencing feeding practices of extreme poor infants and young children in families of working mothers in Dhaka slums : A qualitative study, *PLOS One* 12(2) 1–15. doi.org/10.1371/journal.pone.0172119

Keusch, G. T., Denno, D. M., Black, R. E., Duggan, C., Guerrant, R. L., Lavery, J. V., … Brewer, T. (2014). Environmental enteric dysfunction: Pathogenesis, diagnosis, and clinical consequences. *Clinical Infectious Diseases*, *59*(Suppl 4), S207–S212. doi.org/10.1093/cid/ciu485

Kimani-Murage, E. W., Muthuri, S. K., Oti, S. O., Mutua, M. K., Van De Vijver, S., & Kyobutungi, C. (2015). Evidence of a double burden of malnutrition in urban poor settings in Nairobi, Kenya. *PLOS One*,, *10*(6), 1–17. doi.org/10.1371/journal.pone.0129943

Kinyoki, D. K., Berkley, J. A., Moloney, G. M., Kandala, N.-B., & Noor, A. M. (2015). Predictors of the risk of malnutrition among children under the age of 5 years in Somalia. *Public Health Nutrition*, *18*(17), 1–9. doi.org/10.1017/S1368980015001913

Kinyoki, D. K., Berkley, J. A., Moloney, G. M., Odundo, E. O., Kandala, N.-B., & Noor, A. M. (2016). Space–time mapping of wasting among children under the age of five years in Somalia from 2007 to 2010. *Spatial and Spatio-Temporal Epidemiology*, *16*, 77–87. doi.org/10.1016/j.sste.2015.12.002

Kinyoki, D. K., Kandala, N.-B., Manda, S. O., Krainski, E. T., Fuglstad, G.-A., Moloney, G. M., … Noor, A. M. (2016). Assessing comorbidity and correlates of wasting and stunting among children in Somalia using cross-sectional household surveys: 2007 to 2010. *BMJ Open*, *6*(3), e009854. doi.org/10.1136/bmjopen-2015-009854

Kinyoki, D. K., Moloney, G. M., Uthman, O. A., Kandala, N., Odundo, E. O., Noor, A. M., & Berkley, J. A. (2017). Conflict in Somalia : impact on child undernutrition. *BMJ Global Health* 2(2):e000262. doi.org/10.1136/bmjgh-2016-000262

Kirk, C. M., Uwamungu, J. C., Wilson, K., Hedt-Gauthier, B. L., Tapela, N., Niyigena, P., … Magge, H. (2017). Health, nutrition, and development of children born preterm and low birth weight in rural Rwanda: A cross-sectional study. *BMC Pediatrics*, *17*(1), 1–10. doi.org/10.1186/s12887-017-0946-1

Kismul, H., Acharya, P., Mapatano, M. A., & Hatløy, A. (2017). Determinants of childhood stunting in the Democratic Republic of Congo: Further analysis of Demographic and Health Survey 2013-14. *BMC Public Health*, *18*(1), 1–15. doi.org/10.1186/s12889-017-4621-0

Krasner, S. D., & Risse, T. (2014). External actors, state-building, and service provision in areas of limited statehood: Introduction. *Governance*, *27*(4), 545–567. doi.org/10.1111/gove.12065

Kuchenbecker, J., Jordan, I., Reinbott, A., Herrmann, J., Jeremias, T., Kennedy, G., … Krawinkel, M. B. (2015). Exclusive breastfeeding and its effect on growth of Malawian infants : results from a cross-sectional study. *Paediatrics and international Child Health* 35(1):14-23. doi.org/10.1179/2046905514Y.0000000134

Kumar, A., Kumari, D., & Singh, A. (2015). Increasing socioeconomic inequality in childhood undernutrition in urban India: Trends between 1992-93, 1998-99 and

2005-06. *Health Policy and Planning*, *30*(8), 1003–1016. doi.org/10.1093/heapol/czu104

Lassi, Z. S., Das, J. K., Zahid, G., Imdad, A., & Bhutta, Z. A. (2013). Impact of education and provision of complementary feeding on growth and morbidity in children less than 2 years of age in developing countries: a systematic review. *BMC Public Health*, *13 Suppl 3*(Suppl 3), S13. doi.org/10.1186/1471-2458-13-S3-S13

Lee.s.K, Nam.S.Y, & Hoffman, D. J. (2015). Growth retardation at early life and metabolic adaptation among North Korean children. *Journal of Developmental Origins of Health and Disease*, *6*(4), 291–298. doi.org/10.1017/S204017441500118X

Leung, D. T., Das, S. K., Malek, M. A., Qadri, F., Faruque, A. S. G., Chisti, M. J., & Ryan, E. T. (2015). Concurrent Pneumonia in Children under 5 Years of Age Presenting to a Diarrheal Hospital in Dhaka , Bangladesh. *American Journal of Tropical Medicine and Hygiene*, *93*(4), 831–835. doi.org/10.4269/aj

Lin, A., Arnold, B. F., Afreen, S., Goto, R., Mohammad, T., Huda, N., … Luby, S. P. (2013). Household Environmental Conditions Are Associated with Enteropathy and Impaired Growth in Rural Bangladesh. *American Journal of Tropical Medicine and Hygiene*, *89*(1), 130–137. doi.org/10.4269/ajtmh.12-0629

Lisa.M Sullivan. (2012). Power and Sample Size determination. In *Essesntials of biostatisitcs in Public Health* (Scond Edit, pp. 169–185). Burlington, MA: Jones and Barlett Learning.

Mahmud, A. S., Alam, N., & Metcalf, C. J. E. (2019). Drivers of measles mortality : the historic fatality burden of famine in Bangladesh. *Epidemiology and Infection, 145,* 3361–3369. https://doi.org/10.1017/S0950268817002564

Majid, N., & McDowell, S. (2012). Hidden dimensions of the Somalia famine. *Global Food Security*, *1*, 36–42. doi.org/10.1016/j.gfs.2012.07.003

Marphatia, A. A., Cole, T. J., Grijalva-Eternod, C., & Wells, J. C. K. (2016). Associations of gender inequality with child malnutrition and mortality across 96 countries. *Global Health, Epidemiology and Genomics*, *1*, E6. doi:10.1017/gheg.2016.1

Marriott, B. P., White, A., Hadden, L., Davies, J. C., & Wallingford, J. C. (2012). World Health Organization (WHO) infant and young child feeding indicators: Associations with growth measures in 14 low-income countries. *Maternal and Child Nutrition*, *8*(3), 354–370. doi.org/10.1111/j.1740-8709.2011.00380.x

Martins, P. A., Hoffman, D. J., Fernandes, M. T. B., Nascimento, C. R., Roberts, S. B., Sesso, R., & Sawaya, A. L. (2004). Stunted children gain less lean body mass and more fat mass than their non-stunted counterparts: a prospective study. *British Journal of Nutrition*, *92*, 819 - 825. doi.org/10.1079/BJN20041274

Maxwell, D., & Fitzpatrick, M. (2012). The 2011 Somalia famine : Context , causes , and complications. *Global Food Security* .doi.org/10.1016/j.gfs.2012.07.002

Mbuya, M. N. N., & Humphrey, J. H. (2016). Preventing environmental enteric dysfunction through improved water , sanitation and hygiene : an opportunity for stunting reduction in developing countries. *Marternal and Child Nutrition 12 (Suppl. 1),* 106–120. doi.org/10.1111/mcn.12220

McDonald, C. M., McLean, J., Kroeun, H., Talukder, A., Lynd, L. D., & Green, T. J. (2015). Household food insecurity and dietary diversity as correlates of maternal and child undernutrition in rural Cambodia. *European Journal of Clinical Nutrition*, *69*(2), 242–246. doi.org/10.1038/ejcn.2014.161

Mcdonald, C. M., Olofin, I., Flaxman, S., Fawzi, W. W., Spiegelman, D., & Caulfield, L. E. (2013). The effect of multiple anthropometric deficits on child mortality : meta-analysis of individual data in 10 prospective studies from, (2), 896–901. *American Journal of Clinical Nutrition,* 97(4):896-901. doi: 10.3945/ajcn.112.047639

Mejía Acosta, A., & Fanzo, J. (2012). Fighting Maternal and Child Malnutrition : Analysing the political and institutional determinants of delivering a national multisectoral response in six countries. A synthesis paper. Retrieved from https://www.ids.ac.uk/files/dmfile/DFID_ANG_Synthesis_April2012.pdf

Menon, P., Bamezai, A., Subandoro, A., Ayoya, M. A., & Aguayo, V. (2015). Age-appropriate infant and young child feeding practices are associated with child nutrition in India: Insights from nationally representative data. *Maternal and Child Nutrition*, *11*(1), 73–87. doi.org/10.1111/mcn.12036

Meshram, I. I., Arlappa, N., Balakrishna, N., Mallikharjuna Rao, K., Laxmaiah, A., & Brahmam, G. N. V. (2012). Trends in the prevalence of undernutrition, nutrient & food intake and predictors of undernutrition among under five year tribal children in India. *Asia Pacific Journal of Clinical Nutrition*, *21*(4), 568–576. doi.org/10.1177/1010539512441492

Minoiu, C., & Shemyakina, O. N. (2014). Armed Conclict, household victimization and child health in Côte d'Ivoire. *Development Economics*, *108*(237–255). doi.org/10.1016/j.jdeveco.2014.03.003

Mohiddin, L., Phelps, L., & Walters, T. (2012). Urban malnutrition : a review of food security and nutrition among the urban poor.Retrieved from the SecureNutrition Knowledge Platform (SNKP) website. https://www.securenutrition.org/basic-page/about-us

Moore, P. S., Marfin, A. A., Quenemoen, L. E., Gessner, B. D., Miller, D. S., Toole, M. J., … Sullivan, K. M. (1993). Mortality rates in displaced and resident populations of central Somalia during 1992 famine. *Lancet*, *341*(8850), 935–938. doi.org/10.1016/0140-6736(93)91223-9

Motbainor, A., Worku, A., & Kumie, A. (2015). Stunting is associated with food diversity while wasting with food insecurity among underfive children in East and West Gojjam Zones of Amhara Region, Ethiopia. *PLOS One,*, *10*(8). doi.org/10.1371/journal.pone.0133542

Mukhopadhyay, K., Louis, D., Mahajan, G., & Mahajan, R. (2014). Longitudinal growth and post-discharge mortality and morbidity among extremely low birth weight neonates. *Indian Pediatrics*, *51*(9), 723–726. doi.org/10.1007/s13312-014-0489-6

Mutisya, M., Kandala, N.-B., Ngware, M. W., & Kabiru, C. W. (2015). Household food (in)security and nutritional status of urban poor children aged 6 to 23 months in Kenya. *BMC Public Health*, *15*(1), 1052. doi.org/10.1186/s12889-015-2403-0

Nankumbi, J., & Muliira, J. K. (2015). Barriers to Infant and Child-feeding Practices : A Qualitative Study of Primary Caregivers in Rural Uganda, *Journal of Health,* *Population and Nutrition*, *33*(1), 106–116.

Nguyen, P. H., Headey, D., Frongillo, E. A., Tran, L. M., Rawat, R., Ruel, M. T., & Menon, P. (2017). Changes in Underlying Determinants Explain Rapid Increases in Child Linear Growth in Alive & Thrive Study Areas between 2010 and 2014. *Journal of Nutrition*, 147(3):462-469. doi: 10.3945/jn.116.243949

Ning, T. R., Kimbi, H. K., Nkuo-Akenji, T., Sumbele, I. U. N., & Bopda, O. S. M. (2015). Nutritional status of children in a malaria meso endemic area: cross sectional study on prevalence, intensity, predictors, influence on malaria parasitaemia and anaemia severity. *BMC Public Health*, *15*(1), 1–10. doi.org/10.1186/s12889-015-2462-2

Okafor, G. (2015). The impact of political instability on the economic growth of ECOWAS member countries. *Defence and Peace Economics*, *28*(2), 208–229. doi.org/10.1080/10242694.2015.1092206

Olofin, I., McDonald, C. M., Ezzati, M., Flaxman, S., Black, R. E., Fawzi, W. W., … Penny, M. E. (2013). Associations of Suboptimal Growth with All-Cause and Cause-Specific Mortality in Children under Five Years: A Pooled Analysis of Ten Prospective Studies. *PLOS One*, *8*(5), 1- 10 doi.org/10.1371/journal.pone.0064636

Osei, A., Pandey, P., Spiro, D., Nielson, J., Shrestha, R., Talukder, Z., … Haselow, N. (2010). Household food insecurity and nutritional status of children aged 6 to 23 months in Kailali District of Nepal. *Food and Nutrition Bulletin*, 31(4), 483–494. doi.org/10.1177/156482651003100402

Psaki, S., Bhutta, Z. A., Ahmed, T., Ahmed, S., Bessong, P., Islam, M., … Checkley, W.

(2012). Household food access and child malnutrition: results from the eight-country MAL-ED study. *Population Health Metrics*, *10*, 24. doi.org/10.1186/1478-7954-10-24

Quigley, M. A., Carson, C., Sacker, A., & Kelly, Y. (2016). Exclusive breastfeeding duration and infant infection. *European Journal of Clinical Nutrition*, *70*(12), 1420–1427. doi.org/10.1038/ejcn.2016.135

Rachmi, C. N., Agho, K. E., Li, M., & Baur, L. A. (2016). Stunting, underweight and overweight in children aged 2.0-4.9 years in Indonesia: Prevalence trends and associated risk factors. *PLOS One*, *11*(5), 1–18. doi.org/10.1371/journal.pone.0154756

Rah, J. H., Cronin, A. A., Badgaiyan, B., Aguayo, V. M., Coates, S., & Ahmed, S. (2015a). Household sanitation and personal hygiene practices are associated with child stunting in rural India : a cross-sectional analysis of surveys. doi.org/10.1136/bmjopen-2014-005180

Rah, J. H., Cronin, A. A., Badgaiyan, B., Aguayo, V. M., Coates, S., & Ahmed, S. (2015b). Household sanitation and personal hygiene practices are associated with child stunting in rural India: a cross-sectional analysis of surveys. *BMJ Open*, *5*(2), e005180. doi.org/10.1136/bmjopen-2014-005180

Rahman, M. S., Howlader, T., Masud, M. S., & Rahman, M. L. (2016). Association of low-birth weight with malnutrition in children under five years in Bangladesh: Do mother's education, socio-economic status, and birth interval matter? *PLOS One*, *11*(6), 1–17. doi.org/10.1371/journal.pone.0157814

Randa, J., Whimp, K. A., Abdullahi, A., & Zacchia, P. B. (2015). Somalia economic update : transition amid risks with a special focus on intergovernmental fiscal relations. Retrieved from http://documents.worldbank.org/curated/en/247911468197970788/pdf/100964-WP-P151626-PUBLIC-Box393254B-1st-Edition-Somalia-Economic-Update-Report.pdf

Rannan-Eliya, R., Hossain, S., Anuranga, C., Wickramasinghe, R., Jayatissa, R., & Abeykoon, A. (2013). Trends and determinants of childhood stunting and underweight in Sri Lanka. *Ceylon Medical Journal*, *58*(1), 10–18. doi.org/10.4038/cmj.v58i1.5357

Richard, S. A., Black, R. E., Gilman, R. H., Guerrant, R. L., Kang, G., Lanata, C. F., … Checkley, W. (2012). Wasting is associated with stunting in early childhood. *Journal of Nutrition*, *142*(7), 1291–1296. doi.org/10.3945/jn.111.154922

Rivera, D., Shah, R., Guenther, T., Adamo, M., Koepsell, J., Reyes, C. M., … Marsh, D. R. (2017). Integrated community case management (iCCM) of childhood infection saves lives in hard-to-reach communities in Nicaragua. *Rev. Panam. Salud Pública*, *41*(PG-e66-e66), e66–e66. Retrieved from http://www.scielosp.org/scielo.php?script=sci_arttext&pid=S1020-49892017000100226 NS -Rodriguez-Llanes, J. M., Ranjan-Dash, S., Mukhopadhyay, A., & Guha-Sapir, D. (2016). Looking upstream: enhancers of child nutritional status in post-flood rural settings. *PeerJ*, 4:e1741; DOI 10.7717/peerj.1741

Ruel, M. T., & Alderman, H. (2013). Nutrition-sensitive interventions and programmes:

How can they help to accelerate progress in improving maternal and child nutrition? *Lancet 2013; 382: 536–51*. doi.org/10.1016/S0140-6736(13)60843-0

Saaka, M., & Osman, M. S. (2013). Does Household Food Insecurity Affect the Nutritional Status of Preschool Children Aged 6 – 36 Months ? International *Journal of Population Research*, Volume 2013. doi.org/10.1155/2013/304169.

Salama, P., Assefa, F., Talley, L., Spiegel, P., Veen, A. van der, & Carol A. Gotway. (2001). Malnutrition, Measles, Mortality, and the Humanitarian Response During a Famine in Ethiopia, *JAMA*. 2001;286(5):563–571. doi:10.1001/jama.286.5.563

Salazar, A., Ojeda, B., Dueñas, M., Fernández, F., & Failde, I. (2016). Simple generalized estimating equations (GEEs) and weighted generalized estimating equations (WGEEs) in longitudinal studies with dropouts: guidelines and implementation in R. *Statistics in Medicine*, *35*(19), 3424–3448. doi.org/10.1002/sim.6947

Sawaya, A. L., Martins, A. P., & Hoffman, D. J. (2003). The link between childhood undernutrition and risk of chronic diseases in adulthood: a case study of Brazil. *Nutrition Reviews*, *61*(May), 168–175. doi.org/10.1301/nr.2003.may.168-175

Sawaya, A. L., & Roberts, S. (2003). Stunting and future risk of obesity : principal physiological mechanisms. *Cad. Saúde Pública, Rio de Janeiro, 19*(suppl. 1), 21–28. Retrieved from http://www.scielo.br/pdf/csp/v19s1/a03v19s1.pdf

Senbanjo, I. O., Olayiwola, I. O., Afolabi, W. A., & Senbanjo, O. C. (2013). Maternal and child under-nutrition in rural and urban communities of Lagos state, Nigeria: the relationship and risk factors. *BMC Research Notes*, *6*. doi.org/10.1186/1756-0500-6-

286

Singh abhishek, Singh Ashish, R. F. (2014). Household food insecurity and nutritional status of children and women in Nepal. *Food and Nutrition Bulletin*, *35*(1), 3–12.

SMART (n.d.) SMART. *Standardized Monitoring and Assessment of Relief and Transitions, Manual 2.0*. Retrieved, from https://smartmethodology.org/about-smart/

Smith, A. K., Ayanian, J. Z., Covinsky, K. E., Landon, B. E., Mccarthy, E. P., Wee, C. C., & Steinman, M. A. (2011). Conducting High-Value Secondary Dataset Analysis : An Introductory Guide and Resources, *The Journal of General Internal Medicine* 26(8):920–929. dOI: 10.1007/s11606-010-1621-5

Smith, L. C., & Haddad, L. (2015). Reducing Child Undernutrition: Past Drivers and Priorities for the Post-MDG Era. *World Development*, *68*, 180–204. doi.org/10.1016/j.worlddev.2014.11.014

Sodha, S. V., Menon, M., Trivedi, K., Ati, A., Figueroa, M. E., Ainslie, R., … Quick, R. (2011). Microbiologic effectiveness of boiling and safe water storage in South Sulawesi, Indonesia. *Journal of Water and Health*, *9*(3), 577. doi.org/10.2166/wh.2011.255

Somalia Nutrition Cluster. (2012). *IYCF Strategy and Action Plan for South Central Somalia*. Retrieved from http://moh.gov.so/en/images/publication/IYCF.pdf

Spears, D., Ghosh, A., & Cumming, O. (2013). Open Defecation and Childhood Stunting in India: An Ecological Analysis of New Data from 112 Districts. *PLOS One*, *8*(9), 1–9. doi.org/10.1371/journal.pone.0073784

Srinivasan, C. S., Zanello, G., & Shankar, B. (2013). Rural-urban disparities in child nutrition in Bangladesh and Nepal, 1–15. *BMC Public Health* 2013, 13:581

Stephenson, L. S., Latham, M. C., & Ottesen, E. A. (2002). Malnutrition and parasitic helminth infections. *Parasitology*, *121*(S1), S23. doi.org/10.1017/s0031182000006491

Strengthening Nutrition Security in South Central Somalia (SNS) Consortium. (2015). Nutrition causal analysis study; South and Central Somalia, Retrieved from Reliefweb webaiste. https://reliefweb.int/report/somalia/nutritional-causal-analysis-study-south-and-central-somalia-november-2015

Summers, A., & Bilukha, O. O. (2018). Suboptimal infant and young child feeding practices among internally displaced persons during conflict in eastern Ukraine. *Public Health Nutrition*, *21*(5), 917–926. doi.org/10.1017/S1368980017003421

Scaling Up Nutrition. (2014). Social Mobilisation, Advocacy and Communication for Nutrition. *Scaling Up Nutrition*. Retrieved from https://scalingupnutrition.org/wp-content/uploads/2018/11/Somalia-Social-SUN-Mobilisation-Advocacy-and-Communications-Strategy_2019-2021.pdf

Tanner, S., Leonard, W. R., & Reyes-García, V. (2014). The consequences of linear growth stunting: Influence on body composition among youth in the bolivian amazon. *American Journal of Physical Anthropology*, *153*(1), 92–102. doi.org/10.1002/ajpa.22413

Tette, E. M. A., Nyarko, M. Y., Nartey, E. T., Neizer, M. L., Egbefome, A., Akosa, F., & Biritwum, R. B. (2016). Under-five mortality pattern and associated risk factors: A case-control study at the Princess Marie Louise Children's Hospital in Accra, Ghana. *BMC Pediatrics, 16*(1), 1–11. doi.org/10.1186/s12887-016-0682-y

World Bank. (n.d.). Mortality rate, under-5 (per 1,000 live births). Retrieved from data.worldbank.org/indicator/SH.DYN.MORT?locations=SO

Thomas, S. L., & Thomas, S. D. M. (2004). Displacement and health. *British Medical Bulletin, 69*(October), 115–127. doi.org/10.1093/bmb/ldh009

Toole, M. J., Steketee, R. W., Waldman, R. J., & Nieburg, P. (1989). Measles prevention and control in emergency settings. *Bulletin of the World Health Organization* , *67*(14), 381-388.

Tranchant, J., Justino, P., & Müller, C. (2014). Political Violence , Drought and Child Malnutrition : Emperical Evidence from Andhra Pradesh, India, *HiCN Working Paper* 1–52. Retrieved from https://assets.publishing.service.gov.uk/media/57a089cde5274a27b200028d/60719_HiCN_WP_173.pdf

Tufa, E. G., Tekle, H. A., Solomon, F. B., Angore, B. N., Bekru, E. T., Dake, S. K., & Bobe, T. M. (2018). Magnitude of wasting and underweight among children 6–59 months of age in Sodo Zuria District, South Ethiopia: a community based cross-sectional study. *BMC Research Notes, 11*(1), 1–7. doi.org/10.1186/s13104-018-3880-x

Tuffrey, V., & Hall, A. (2016). Methods of nutrition surveillance in low-income countries. *Emerging Themes in Epidemiology, 13*(1), 4. doi.org/10.1186/s12982-016-0045-z

United Nations Development Program (UNDP). (2013). *Improving child nutrition. The* *achievable imperative for global progress*. Retrieved from https://doi.org/978-92-806-4686-3

United Nations Development Program (UNDP). (2015). *Gender in Somalia Brief*. Retrieved from https://www.undp.org/content/dam/rbas/doc/Women's Empowerment/Gender_Somalia.pdf

United Nations Development Program (UNDP)UNDP. (2016). Human Development Report 2016 Human Development for Everyone, 232–233. Retrieved from http://hdr.undp.org/sites/default/files/2016_human_development_report.pdf

United Nations High Commission for Refugees (UNHCR). (2018). *Global Trends, Forced Displacement in 2018*. Retrieved from https://www.unhcr.org/globaltrends2018/

United Nations Children's Fund / World Health Organization /World Bank Group. (2018). Levels and trends in child malnutrition: Key findings of the 2018 edition. Retrieved from https://www.who.int/nutgrowthdb/2018-jme-brochure.pdf?ua=1

United Nations Children's Fund (UNICEF). (2012). World Health Organization / United Nations Children's Fund Joint statement on Integrated Community Case Management: An equity-focused strategy to improve access to essential treatment services for children, (iCCM). Retrieved from https://www.who.int/maternal_child_adolescent/documents/statement_child_services_access_whounicef.pdf

United Nations Children's Fund (UNICEF). (2015). UNICEF's approach to scaling up nutrition for mothers and their children. Retrieved from https://www.unicef.org/nutrition/files/Unicef_Nutrition_Strategy.pdf

United Nations Children's Fund (UNICEF). (2016). Situation Analysis of Children in Somalia 2016. Retrieved from https://www.unicef.org/somalia/SOM_resources_situationalaysissummary.pdf

Victora, Cesar G, Adair, L., Fall, C., Hallal, P. C., Martorell, R., Richter, L., … Fogel, R. (2008). Maternal and child undernutrition: consequences for adult health and human capital. *Lancet (London, England)*, *371*(9609), 340–357. doi.org/10.1016/S0140-6736(07)61692-4

Victora, Cesar Gomes, Onis, M. de, Hallal, P. C., Blössner, M., & Shrimpton, R. (2017). Worldwide Timing of Growth Faltering : Revisiting Implications for Interventions, *125*(3). doi.org/10.1542/peds.2009-1519

Vollmer, S., Bommer, C., Krishna, A., Harttgen, K., & Subramanian, S. V. (2017). The association of parental education with childhood undernutrition in low- and middle-income countries : comparing the role of paternal and maternal education, *International Journal of Epidemiology* 46(1), 312–323. doi.org/10.1093/ije/dyw133

Waber, D. P., Bryce, C. P., Girard, J. M., Zichlin, M., Fitzmaurice, G. M., & Galler, J. R. (2014). Impaired IQ and academic skills in adults who experienced moderate to severe infantile malnutrition: a 40-year study. *Nutritional Neuroscience*, *17*(2), 58–64. doi.org/10.1179/1476830513Y.0000000061

Walker, S. P., Chang, S. M., & Powell, C. a. (2007). The association between early childhood stunting and weight status in late adolescence. *International Journal of Obesity (2005)*, *31*(2), 347–352. doi.org/10.1038/sj.ijo.0803383

Wamani, H., Åstrøm, A. N., Peterson, S., Tumwine, J. K., & Tylleskär, T. (2007). Boys are more stunted than girls in Sub-Saharan Africa : a meta-analysis of 16 demographic and health surveys, *BMC Pediatrics*, 7(17), 1–10. doi.org/10.1186/1471-2431-7-17

World Health Organization / United Nations Children's Fund /WFP. (2014). Global nutrition targets 2025: Wasting policy brief. *Global Nutrition Targets 2025*, (WHO/NMH/NHD/14.8).Retrieved from https://apps.who.int/iris/bitstream/handle/10665/149023/WHO_NMH_NHD_14.8_eng.pdf?ua=1

World Health Organization (WHO) / United Nations Children's Fund (UNICEF). (2017). Progress on Drinking Water , Sanitation and Hygiene. 2017 Update and SDG Baselines. Retrieved from https://www.who.int/mediacentre/news/releases/2017/launch-version-report-jmp-water-sanitation-hygiene.pdf. WHO (2000), The management of nutrition in major emergencies.. Retrieved from https://apps.who.int/iris/handle/10665/42085

World Health Organization (WHO). (2007). Indicators for assessing infant and young child feeding practices.. Retrieved from https://www.who.int/maternal_child_adolescent/documents/9789241596664/en/

World Health Organization (WHO). (2008). Closing the gap in a generation: Health equity through action on the social determinants of health. Final Report of the

Commission on Social Determinants of Health. Retrieved from https://www.who.int/social_determinants/thecommission/finalreport/en/n

World Health Organization (WHO). (2014a). Global Nutrition Targets 2025. Retrieved from http://apps.who.int/iris/bitstream/10665/149018/1/WHO_NMH_NHD_14.2_eng.pdf?ua=1

World Health Organization (WHO). (2014b). Global nutrition targets 2025: Stunting policy brief (WHO/NMH/NHD/14.3). Retrieved from http://apps.who.int/iris/bitstream/10665/149019/1/WHO_NMH_NHD_14.3_eng.pdf?ua=1

World Health Organization (WHO). (2015a). Improving nutrition outcomes with better water, sanitation and hygiene : practical solutions for policies and programmes. Retrieved from https://www.who.int/water_sanitation_health/publications/washandnutrition/en/

World Health Organization (WHO). (2019a). Malaria: Integrated community case management of malaria. Retrieved August 3, 2019 from https://www.who.int/malaria/areas/community_case_management/overview/en/

World Health Organization (WHO). (2019b). Malnutrition. Retrieved August 3, 2019, from www.who.int/news-room/fact-sheets/detail/malnutrition

WHO, UNICEF, WFP, FAO, & FSNAU. (2010). Somali Nutrition Strategy. Retrieved from extranet.who.int/nutrition/gina/sites/default/files/SOM 2010 Nutrition Strategy.pdf

Wilkinson, R., & Pickett, K. (2010). Poverty or inequality. *The Spirit Level: Why Equality is better for everyone*. (pp 15 -30) Bloomsbury Press: New York

Wolf, J., Prüss-Ustün, A., Cumming, O., Bartram, J., Bonjour, S., Cairncross, S., … Higgins, J. P. T. (2014). Systematic review: Assessing the impact of drinking water and sanitation on diarrhoeal disease in low- and middle-income settings: Systematic review and meta-regression. *Tropical Medicine and International Health*, *19*(8), 928–942. doi.org/10.1111/tmi.12331

Wong, H. J., Moy, F. M., & Nair, S. (2014). Risk factors of malnutrition among preschool children in Terengganu, Malaysia: a case control study. *BMC Public Health*, *14*(1), 785. doi.org/10.1186/1471-2458-14-785

World Bank. (2013). Improving nutrition through multisectoral approaches, Retrieved from http://documents.worldbank.org/curated/en/2013/01/17211210/improving-nutrition-through-multisectoral-approaches

World Food Program. (2018). 10 Facts About Hunger In Somalia Retrieved from https://www.wfp.org/stories/10-facts-about-hunger-somalia

World Food Programme. (2012). Trend Analysis of Food and Nutrition Insecurity in Somalia 2007 -2012. Retrieved from http://documents.wfp.org/stellent/groups/public/documents/ena/wfp254879.pdf?_ga=2.103244868.572603886.1504328464-658046347.1489836709