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Examining the Impact of Household Access to Water and Sanitation on Child Malnutrition in Ethiopia

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ABSTRACT

Introduction: Millions of children worldwide die before they reach their fifth birthday. Approximately 50% of all deaths in children are associated with malnutrition. Although remarkable improvements have been seen in the past few decades, child malnutrition remains a major public health problem in Ethiopia. Malnutrition has been linked to various morbidities and as the underlying cause of 57% of mortality in the country. It is caused by complex and multidimensional biological, social economic, and environmental factors. There are scarce literatures examining the environmental factors, such as access to water and sanitation, on the likelihood of child malnutrition as measured by stunting, wasting, and underweight in Ethiopia, which the current study sought to investigate.

Aim: The primary aim of this study was to examine the relationship between households' access to water and sanitation facilities and the likelihood that a child will become stunted or wasted or underweight.

Methods: The study utilized a nationally representative data from 2011 Ethiopia Demographic and Health Survey. The sample size was 9,611 children aged 0-59 months. A weighted descriptive statistical analysis was performed to examine the frequency distribution of the study's primary independent variables (sanitation and water), dependent variables (childhood stunting, wasting, and underweight), and all other variables included in the study. Weighted bivariate analysis was conducted using logistic regression to quantify association between stunting, wasting, and being underweight and different independent variables. Weighted multivariate logistic regression analysis was performed to control for potential confounders while examining the relationship between the primary independent and dependent variables. Odds ratios, 95% confidence limits, and p-value were calculated. We considered three sets of potential confounders: child's (child's gender, child's age, and child's size at birth diarrheal disease, fever), maternal (maternal education) and household characteristics (maternal BMI, place of residence, wealth index, stool disposal, time to get water). Only variables that showed significant association (p-value<0.05) with each dependent variable in the bivariate analysis were selected and adjusted for in the multivariate analysis A p-value less than 0.05 was considered statistically significant.

Main results: Approximately 44%, 10%, and 29% of the children under-five years of age were stunted, wasted, and underweight, respectively. About 54% of the study population used unimproved source of drinking water and about 82% used unimproved sanitation facility. Our bivariate logistic analysis revealed that children in households with unimproved source of drinking water had higher odds of stunting compared to children in households with improved drinking water source (OR: 1.2; 95% CL 1.02-1.34). Adjustment for child's characteristics yielded AOR: 1.2; 95% CL 1.0-1.4. Addition of maternal characteristics attenuated this association (AOR: 1.1; 95% CL 1.0-1.3 1.0; 95% CL 0.8-1.2). Finally, inclusion of household characteristics showed stunting was not associated with unimproved source of drinking water (AOR: 1.0; 95% 0.8-1.2). The bivariate analysis revealed household access to unimproved source of drinking water was not significantly associated with wasting (OR: 1.0; 95% CL 0.8-1.3) and underweight (OR: 1.2; 95% CL 1.0-1.4). Adjustment of child, maternal, and household characteristic showed an inverse association between source of drinking water and wasting

(AOR: 0.7; 95% CL 0.6-0.9). In the bivariate analysis, access to unimproved sanitation was significantly associated with stunting (OR: 1.3; 95% CL 1.02-1.74) and underweight (OR: 1.5; 95% CL 1.1-2.1). Compared to children living in homes with access to improved sanitation facility, children in household with unimproved sanitation facility had 1.4 increased odds of being stunted (95% CL 1.1-1.9) after adjustment for child's characteristics. Adjustment of child, maternal, and household characteristics attenuated this association (AOR: 1.1; 95% CL 0.8-1.5). Children in household with unimproved sanitation facility had higher odds of being underweight after adjusting for child characteristics (AOR: 1.6; 95% CL 1.2-2.2). Addition of maternal characteristic reduced the association (AOR: 1.5; 95% CL 1.1-2.0). Finally, the addition of household characteristics further attenuated this association (AOR: 1.4; 95% CL 1.1-1.9). Children from households with improved water but unimproved sanitation had higher odds of wasting and being underweight compared to children living in household with both services: AORs adjusted for child's characteristics were 2.3 (95% CL 1.3-4.3) for wasting and 2.4 (95% CL 1.6-3.6) for underweight; when maternal characteristics were included, AORs were 2.2 (95% CL 1.2-4.1) and 2.1 (95% 1.4-3.3) for wasting and underweight, correspondingly; finally, when household characteristics were included AORs were 2.0 (95% CL 1.1-3.9) and 1.9 (95% CL 1.2-3.0), respectively.

Conclusion: Our results suggest that household access to unimproved source of drinking water and sanitation increase the likelihood of malnutrition. Therefore, initiatives to increase access to improved sources of drinking water and sanitation facilities along with nutritional intervention could help alleviate the high burden of malnutrition in Ethiopia.

Keywords: Stunting, wasting, underweight, malnutrition, undernutrition, Ethiopia, sanitation, water, Demographic and Health Survey

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ABBREVIATIONS

AIDS	Acquired Immunodeficiency Syndrome
AOR	Adjusted odds ratio
BMI	Body Mass Index
CL	Confidence limit
CSA	Central Statistical Agency
DHS	Demographic and Health Survey
EDHS	Ethiopia Demographic and Health Survey
EE	Environmental entropathy
FAO	Food and Agriculture Organization
HAZ	Height-for-age Z-score
HIV	Human Immunodeficiency Virus
JMP	Joint Monitoring Program
MDG	Millennium Development Goals
MoH	Ministry of Health
OR	Odds ratio
P-value	Probability value (observed significant level)
SAS	Statistical Analysis Software
SD	Standard deviation
STD	Sexually Transmitted Disease
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
VIP latrine	Ventilated improved pit latrine
WAZ	Weight-for-age Z-score
WB	World Bank
WFP	World Food Program
WHO	World Health Organization
WASH	Water/Sanitation/Hygiene
WHZ	Weight-for-age Z-score

CHAPTER I

INTRODUCTION

1.1 Background

Every year, approximately three million children worldwide die before they reach their fifth birthday. About 50 percent of all deaths in children are associated with malnutrition (United Nations International Children's Emergency Fund (UNICEF), 2016). Globally, great strides have been made to reduce the prevalence of malnutrition. Between 1990 and 2014, the global prevalence of children that were considered chronically malnourished (stunted) fell from 39.6 percent to 23.8 percent (World Health Organization (WHO), UNICEF, World Bank (WB), 2015). Thus, though the prevalence of child malnutrition is declining, it remains a public health challenge.

The term malnutrition refers to both over- and undernutrition (Adelo et al., 2015; Black et al., 2013). This project focuses only on undernutrition, which manifests itself in different forms in children such as wasting (low weight for height) or stunting (low height for age) or underweight (low weight for age) (Dangour et al., 2013). Although common in all parts of the world, the global burden of undernutrition is disproportionately distributed, with higher prevalence of affected children living in low- and middle-income countries (Adelo et al., 2015; Fenn et al., 2012). Compared to other regions of the world, Sub-Saharan Africa and Asia have some of the world's highest percent of undernourished children (UNICEF, 2006).

Ethiopia is one of the countries in Sub-Saharan Africa where child malnutrition is a prevailing public health problem (Altare et al., 2016). Between 2000 and 2011 the prevalence of stunting among Ethiopian children less than five years declined from 57 percent to 44 percent (Altare et al., 2016; de Onis et al., 2013; Haile et al., 2016). Despite this progress, Ethiopia still has one of the highest prevalence of childhood undernutrition among East African countries (Altare et al., 2016; Haile, et al., 2016). Malnutrition in Ethiopia is reported to be is the principal cause of 57 percent of child mortality (Altare et al., 2016).

There are multiple and interrelated factors that affect the nutritional status of children. The conceptual framework constructed by UNICEF illustrates that malnutrition is driven by risk factors at different levels from immediate level to underlying and basic levels (UNICEF, 1990). At the immediate level, it is caused by inadequate dietary intake and/or poor health status. The underlying level is associated with food insecurity, poor household environments (i.e. unclean water, poor hygiene, and unsafe sanitation), lack of maternal and child care, and poverty. Finally, the basic causes of child malnutrition include the political, cultural, and economic structures that make it possible for households and communities to gain proper nutrition (UNICEF, 1990; Silva, 2005). Past studies have focused on the effects of some of the underlying determinates like maternal education and access to health care on child malnutrition (Silva, 2005). In this study we focus on the impact of the underlying environmental predicators, namely household access to water and sanitation, on child's nutritional status.

1.2 Purpose of study

To the best of our knowledge, there are scarce researches that evaluate the impact of access to improved water and sanitation on child malnutrition on a national scope in Ethiopia (Silva, 2005). Many of the research conducted examines risk factors, including water and sanitation, on a regional and a community level (Fenn et al., 2011). One previous study was conducted on a national level by Silva using Ethiopia Demographic and Health Survey (EDHS) 2000 data. She analyzed the link between access to water and sanitation and child malnutrition.

Unlike the current study, her research only assessed the association of those environmental factors with childhood stunting and underweight (Silva, 2005).

The present study examines the impact of access to water and sanitation on child malnutrition as measured by stunting, wasting, and underweight in Ethiopia using the most current 2011 EDHS. This will provide a more comprehensive outlook on the association between the risk factors and childhood malnutrition, and will help drive public health interventions in Ethiopia.

1.3 Research question and hypothesis

1) Is there an association between households' access to source of drinking water and malnutrition, as indicated by (*i*) stunting, (*ii*) wasting, and (*iii*) underweight, in Ethiopian children between the ages of 0-59?

    Compared to household with access to improved source of drinking water, households that have access only to **unimproved** drinking water are more likely to have a child who is stunted or wasted or underweight.

2) Is there an association between households' access to sanitation facility and malnutrition, as indicated by (*i*) stunting, (*ii*) wasting, and (*iii*) underweight, in Ethiopian children between the ages of 0-59?

    Compared to households with access to improved sanitation facilities, households that have access to only **unimproved** sanitation facilities are more likely to have a child within the household who is stunted or wasted or wasted.

3) Is there an association between households' access to both services (improved source of drinking water **and** improved sanitation facility) and malnutrition, as

indicated by (*i*) stunting, (*ii*) wasting, and (*iii*) underweight, in Ethiopian children between the ages of 0-59?

Compared to households with access to both services, households that have access to only improved water and unimproved sanitation facilities or improved sanitation facilities and unimproved water or unimproved water and unimproved sanitation facilities are more likely to have a child within the household who is stunted or wasted or underweight.

1.4 Thesis organization

This paper is organized into five chapters. Chapter one is an introduction and covers background information, statement of the problem, objective of the study, research question, and hypothesis. Chapter two provides a review of the literature. The following chapter gives detailed explanation of the sample, measures, and method of analysis used for the study. Chapter four gives the results of the study finding. The final chapter will present the discussion, study limitations and strength, conclusion, and recommendations.

CHAPTER II

LITERATURE REVIEW

2.1 Definition of malnutrition and child nutritional indicators

The World Food Program (WFP) defines malnutrition as “a state in which the physical function of an individual is impaired to the point where he or she can no longer maintain adequate bodily performance process such as growth, pregnancy, lactation, physical work and resisting and recovering from disease” (WFP, 2000). Malnutrition is broad term that is used to refer to a wide range of diseases resulting from deviation from adequate nutrition (Blossner, 2005). It includes undernutrition, which results from inadequacy of food, and overnutrition, which is an outcome of excessive dietary intake (Muller and Jahn, 2009; Adelo et al., 2015). In the context of developing nations, undernutrition is the primary issue of concern, although the prevalence of overnutrition is increasing (Block et al. 2012).

The impact of malnutrition is felt by all groups of individuals in a society; however, infants and young children are the most susceptible, for they have a higher nutritional demand for growth and development (Blossner, 2005). One method used to measure the nutritional status of children under age five is to examine their nutrition-related outcomes, such as growth retardation and weight loss (de Onis, 2000). The WHO recommends several different methods to examine malnutrition, one of which is by using anthropometric measures (Wang & Chen, 2012). Measurements of nutritional anthropometry reflect the physical growth of children and are based on measurements derived from measurements of child’s height, weight, and age (Blossner, 2005). The three most commonly used indicators of undernutrition in children are height-for-age (HAZ), weight-for-height (WHZ), and weight-for-age (WAZ) (de Onis et al., 1993; Wang & Chen, 2012).

The indices of height-for-age reflect long-term nutritional deficiency. It measures a child's body relative to age, which reflects cumulative linear growth. Children whose height-for-age is less than -2 standard deviations (SD) away from the WHO reference population median are said to be stunted, chronically malnourished (Wang and Chen, 2012; WHO, 2006). These children fail to reach their potential height for their age; they exhibit short stature-for-age as a result of long-term inadequate nutritional intake and repeated infection (de Onis, 2000). The cause of stunting differs from region to region; however, an increased prevalence of low height-for-age in children has been broadly associated with socioeconomic status (Gorstein et al., 1994).

Weight-for-height is used as indicator of current nutritional status. It is used to assess acute malnutrition. A child who experiences a low weight-for-height, known as wasting, has a WHZ below -2 SD away from the median of the international reference population (Wang & Chen, 2012; WHO, 2006). These children appear thin. Wasting occurs as a result of acute starvation and/or severe disease like, diarrhea and pneumonia (de Onis, 2000). In emergency conditions, such as famine, the prevalence of wasting increases. Weight-for-height can be calculated without available data of children's age. This makes it a useful tool to assess malnutrition in countries where birth records are unavailable or undependable (Gorstein et al., 1994).

Weight-for-age is the most commonly used to examine nutritional status. It is a way to express body mass relative to age. For a child who's WAZ falls below -2 standard deviation from the median of the reference population are identified as underweight (Wang and Chen, 2012;WHO, 2006). Children can become underweight as a result of a prolonged or acute malnutrition. This composite indicator, thus, reflects wasting and stunting. The nature of this indicator makes it hard to distinguish between weight-for-height and height-for-age. In essence, children can be underweight if they are stunted, wasted, or both (Gorstein et al., 1994). Weight-for-age among children is indicative of the nutritional status and health of a population (de Onis, 2000; Gorstein et al., 1994).

2.2 Consequences of Malnutrition

Malnutrition is known to have important long- and short-term effects on children (Glewwe et al. 2007). Its effects are not only associated with child mortality, but it also has persistent effects on those who survive (Silva, 2005, Victora et al., 2008). Childhood undernutrition has been shown to increase the risk of infection like diarrhea and pneumonia and further increasing the likelihood of undernutrition (Black et al., 2008; Lin et al., 2013). Furthermore, children who do not receive adequate nutritional support during the early stages of life are more likely to die prematurely, experience linear growth restriction, delay in motor development, cognitive impairment, and have behavioral and social problems (Adelo et al., 2015; Black et al., 2013; Victora et al., 2008). Daniels and Adair (2004), examining the association between childhood malnutrition and completion of grade school and high school in the Philippines revealed that undernutrtion undermines educational attainment. They reported that stunting was associated with lower school performance, delayed school entrance, higher grade repetition and dropout rate, and lower graduation rate from primary and secondary school.

Dietary deficiencies during childhood also plays a significant role in determining if the child will become malnourished or develop severe health complications later in adulthood (Victora et al., 2008). Growth failure during early stages of life has also been linked to short stature in adulthood and reduced adult economic productivity (Victora et al., 2008; Lin et al., 2013). Additionally, malnourished children who gain weight quickly after infancy are likely to suffer chronic conditions such as hypertension and type II diabetes (Victora et al., 2008).

2.3 The global burden of malnutrition

In spite of significant improvement made to reduce the global prevalence of child malnutrition in the past few decades, a large number of children worldwide remain malnourished (Steiber et al., 2015). According to data collected from the collaborative efforts of UNICEF, WHO, and World Bank (WB), there were an estimated population of 667 million children below the age of five in the world in 2014 (UNICEF-WHO-WB, 2015; UNICEF-WHO-WB, 2016). Among these children, 159 million children, or approximately 24%, were stunted (UNICEF-WHO-WB, 2015; UNICEF-WHO-WB, 2016). The number of children considered stunted in 2014 declined from the 225 million children who were stunted in 1990. In 2014, a total number of 50 million - around 7.5% of the world children under-five year olds- were wasted (UNICEF-WHO-WB, 2015; UNICEF-WHO-WB, 2016). Similarly, the proportion of children who were underweight has also declined (UNICEF-WHO-WB, 2015; UNICEF-WHO-WB, 2016). In 1990, 161 million children were affected by underweight globally; the proportion affected declined to 95 million in 2014 (UNICEF-WHO-WB, 2015; UNICEF-WHO-WB, 2016).

2.4 The burden of child malnutrition in Ethiopia

Child malnutrition is one of the biggest challenges and most serious public health problem faced by Ethiopians (Alemu et al., 2005; Young Lives, 2000). Results of the 2011 EDHS showed that 44% of all children in Ethiopia aged 0-59 months were stunted. The report also indicated that 29% and 10% of children in the same age group were underweight and wasted, respectively (EDHS, 2011). These figures show that child malnutrition levels are high and highlight the severity of the problem in the country.

Whilst Ethiopia has made significant improvement in the past decade to reduce the prevalence of malnutrition in children age under-five years, the country continues to have one of the most undernourished people in the world (Headey, 2014). Between 2000 and 2011, for example, the proportion of chronically malnourished children declined from 57.8% to 44%, respectively. Despite this progress, however, childhood malnutrition ranks above the average for Sub-Saharan Africa (Black et al, 2008; Young Lives, 2000).

Poor nutritional status in Ethiopia threatens the lives of millions of children; undernutrition contributes to approximately 53% of child mortality (Alemayehu et al., 2015; Asfaw et al., 2015). It is estimated that one in every 17 children in Ethiopia dies before celebrating his/her first birthday, and one in every 11 dies before reaching age five (Alemayehu et al). Furthermore, Ethiopia’s high rate of malnutrition also negatively impacts the social and economic aspect of the country. According to a study that examined the social and economic cost of undernutrition in Africa, results showed that 44% of the health costs associated with undernutrition occurs before the child turns one year old. It also estimated that undernutrition costs 55.5 billion Ethiopian birr, or $4.7 billion USD, annually, which is equivalent to 16.5% of GDP during the period 2004 to 2009 (African Union Commission, 2014).

Recognizing the seriousness of the problem, the Ethiopian government has focused on reducing the prevalence of malnutrition in children by implementing different nutritional programs like, National Nutrition Strategy and National Nutrition Program (Fantahun et al., 2016). Additionally, the country has collaboratively worked with international organizations such, WHO and UNICEF, to help improve the nutritional status of children. Though the country’s individual and collaborative efforts have helped the country witness improvements in children's nutritional status, Ethiopia still must work to tackle the malnutrition challenge.

2.5 Overview of water source and sanitation classifications

The Joint Monitoring Program for Water Supply and Sanitation is a combined monitoring effort of the World Health Organization (WHO) and United Nations Children's Fund (UNICEF). It was established to monitor the trends and progress of the global water and sanitation coverage and to support countries in their aim to monitor the water and sanitation sector. The data gathered by the JMP were utilized by the United Nations to track the progress toward achieving the MDG 7 Target 7C, which sought to halve the proportion of the population in developing countries without access to safe drinking water and basic sanitation (UN General Assembly, 2000; WHO/UNICEF-JMP, 2015).

According to JMP the term "improved sanitation" or "improved sanitation facilities" refers to those source that hygienically separate and dispose human waste from coming in direct contact with humans. WHO/UNICEF defines access to sanitation as proportion of people with access to either of the following improved sanitation facilities: flush/pour flush toilet connected to piped sewer system or septic tank or toilet. A household is considered as having access to "improved" drinking water if it obtains water from sources that protect it from outside contamination, especially fecal matter. An "improved" source of drinking water consists of one of the following: a piped household connection, public standpipe/borehole, protected dug well or spring, and/or rainwater collection (WHO/UNICEF-JMP, 2015). Table 1 displays the list of water sources and sanitation facilities that are considered to be improved and unimproved.

Table 1 Improved and unimproved water supply and sanitation facilities

Improved Drinking Water	Unimproved Drinking Water
Piped water into dwelling, yard or plot Public tap or standpipe Tube well/borehole Protected dug well Protected spring Rainwater	Unprotected dug well Unprotected spring Cart with small tank or drum Tanker truck Surface water (river, dam, lake, pond, stream, canal, irrigation channel) Bottled water*
Improved Sanitation	**Unimproved Sanitation**
Flush or pour-flush to: →Piped sewer system →Septic tank →Pit latrine Ventilated improved pit (VIP) latrine Pit latrine with slab Composting toilet	**Any of the following facilities:** Flush or pour-flush to elsewhere (that is, not to piped sewer system, septic tank or pit latrine) Pit latrine without slab/open pit Bucket Hanging toilet or hanging latrine **Shared facilities of any type** **No facilities, bush or field**

Bottled water is considered to be improved only when the household uses water from another improved source for cooking and personal hygiene; where this information is not available, bottled water is classified on a case-by-case basis
Source: WHO/ UNICEF, 2015 JMP

2.6 Global WASH sector and MDGs

Access to safe drinking water and adequate sanitation has been recognized as human rights (United Nations General Assembly, 2010). Yet, an estimated 663 million people in the world are without access to clean drinking water and 2.4 billion people are without basic sanitation facilities (WHO/UNICEF, 2015). Consequently, many individuals worldwide, especially children and women, are faced with detrimental health outcomes due to consumption of unclean drinking water and exposure of unsanitary conditions, coupled by inadequate hygienic practices (Cheng et al., 2012; World Bank, 2008; UNICEF, 2006). According to the WHO, 10 percent of the global burden of disease could be prevented if improvements of these basic necessities are met (Pruss-Ustun, 2008). As a result, global health organization and local organizations have been working to ensure human health through provision of safe water, sanitation, and hygiene (WASH) program (Cheng et al., 2012; United Nations World Water Assessment Program, 2010)

In September 2000, leaders from all over the world convened at the United Nations Millennium Summit to adopt the Millennium Declaration and agree to achieve eight Millennium Development Goals (MDGs) by the end of 2015. The eight goals consists of: "eradicate extreme poverty and hunger; achieve universal primary education; promote gender equality and empower women; reduce child mortality; improve maternal health; combat HIV/AIDS, malaria and other diseases; ensure environmental sustainability; and develop a global partnership for development" (United Nations (UN), 2000).

Water and sanitation are critical components of the Millennium Development Goal 7 that sought to "ensure environmental sustainability". One target of this goal called for nations to halve the proportion of people, who in 1990, were without access to safe drinking water and sanitation by 2015 (UN, 2000). The world met the target of halving the proportion of people without access to improved drinking water in 2010, five years before the deadline (WHO, 2012; WHO/UNICEF, 2015). Since 1990, 2.4 billion of the world's population has gained access to improved water. However, there is still cause for concern as millions of people remain without access (WHO/UNICEF, 2015). As shown in Figure 1, access to improved sources of drinking water is unevenly distributed. Sub-Saharan Africa, in particular, is home to nearly all of the world's population with less than 50 percent access to improved source of drinking water (WHO/UNICEF, 2015).

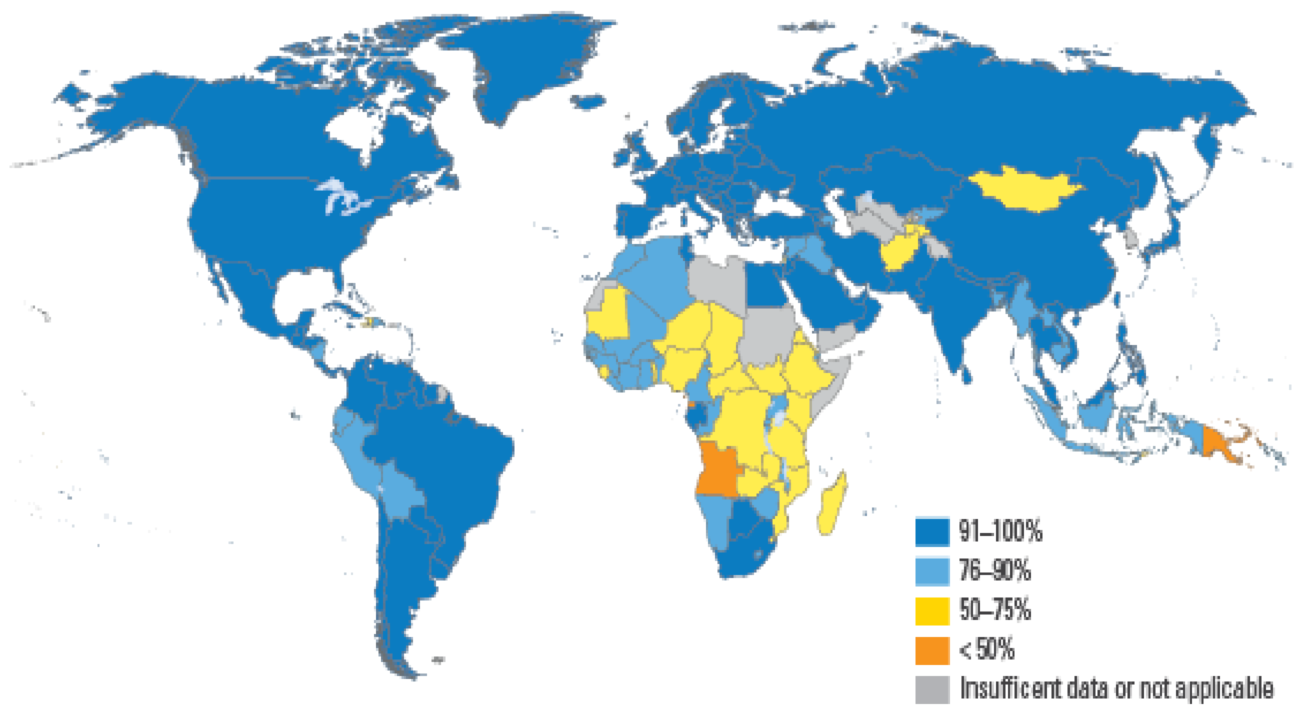

Figure 1 Proportion of the global population using improved sources of drinking water in 2015 (Source: WHO/UNICE, 2015)

Concerning sanitation, although estimable progress has been made, the MDG target to increase the proportion of people worldwide with access to improved sanitation from 54 percent in 1990 to 77 percent by 2015 was missed by approximately 700 million people (WHO/UNICEF, 2015). In Sub-Saharan Africa, sanitation coverage is estimated to be the lowest of any of the continents, where less than 20 percent of the population has gained access to improved sanitation coverage (WHO/UNICEF, 2015).

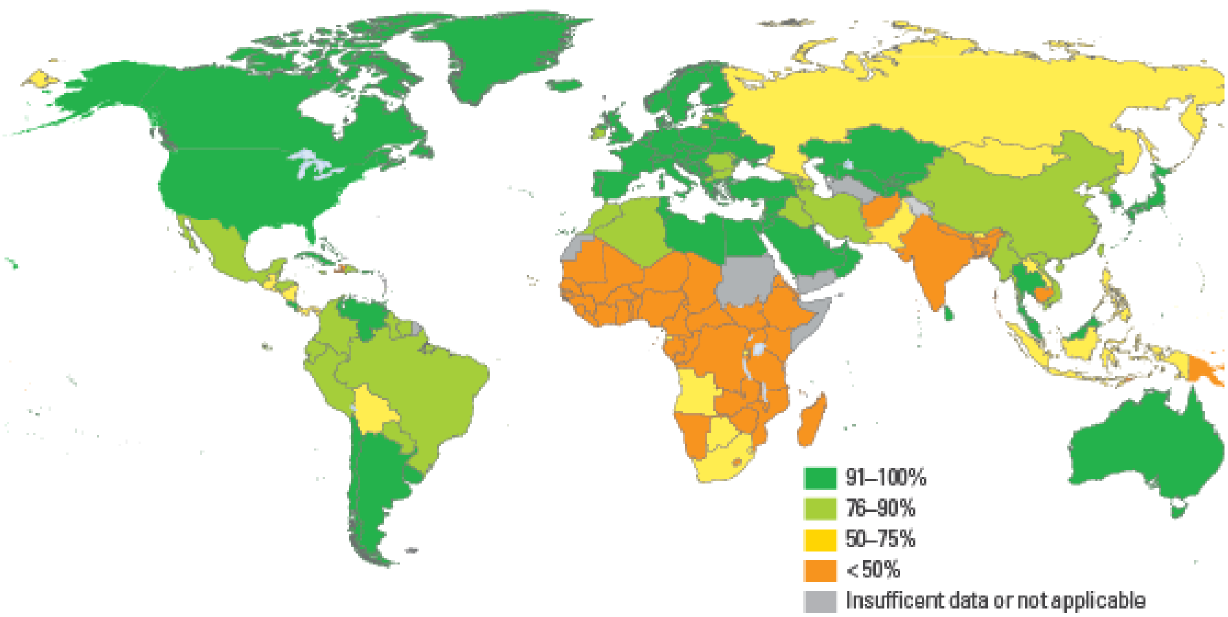

Figure 2 Proportion of the global population using improved sanitation services in 2015 (Source: WHO/UNICE, 2015)

2.7 Water and sanitation coverage in Ethiopia

Access to improved water and sanitation has increased in Ethiopia since 1990. In 2015, the country attained 57 percent water coverage, an increase from its 14 percent coverage in 1990, achieving the MDG target of reducing the proportion of the population using unimproved water (WHO/UNICEF, 2015). The key improvement the country made with regards to sanitation is the significant progress in reducing open defecation, which fell from 92 percent in 1990 to 28 percent in 2015 (WHO/UNICEF, 2015). The sanitation coverage in Ethiopia also showed changes although not enough to reach the MDG target for sanitation. During the same period it increased from 3 percent in 1990 to 28 percent in 2015 (WHO/UNICEF, 2015). Although the changes in the overall coverage for both water and sanitation are encouraging, many people in the country still lack access to safe drinking water and adequate sanitation. According to WaterAid, an international non-organization organization, more than 71 million people are still without access to adequate sanitation and 42 million are without safe drinking water (WaterAid, 2016). The lowest access safe water and sanitation are found in rural regions of Ethiopia. In 2015, only 49 percent of the rural population had access to improved drinking water source, while 35 percent still unimproved sources of water and 16 percent use surfaces water (WHO/UNICEF, 2015).

2.8 Overview of the causal pathway between WASH and Malnutrition

The relationship between poor water, sanitation, and hygiene childhood malnutrition is complex and multidimensional (Ngure et. al, 2014). Researchers have proposed that poor WASH is linked to malnutrition through a range of direct and indirect mechanisms. Unclean water, inadequate sanitation, and poor hygienic practice are associated with malnutrition via direct mechanism that involves the ingestion of environmentally fecal contaminated substances, water, and/or food that results in infectious diseases like diarrhea, environmental enteric infections, and intestinal infections (Dangour et al., 2013). Some of the indirect mechanisms by which WASH impacts nutritional status of children include time taken away from childcare to collect water that is not readily available at home, the cost of water purchased from vendors, and unavailability of sufficient water for consumption and hygienic practices like hand washing after defecation (Dangour et al., 2013).

The most commonly acknowledged pathway between poor WASH and nutritional status is through diarrheal disease. Annually, poor water and sanitation are responsible for an estimated 5.4 billion cases of diarrhea predominantly among children ages under-five years (World Bank, 2008). A research conducted by Mihrete et al. (2014) using the 2011 EDHS suggests that poor hygienic practices and unsafe disposal of child's stool are predictors of diarrheal disease among children under-five. Other researchers have proposed that approximately half of the maternal and child malnutrition from inadequate WASH is mainly through the synergy between malnutrition and diarrhea (Ngure et al., 2014; World Bank, 2008). The relationship between malnutrition and diarrhea is bidirectional (Scrimshaw et al., 1968). That is malnutrition compromises the immune system and increases the risk of an illness; and in turn, repeated and prolonged episodes of diarrhea reduces results in loss of appetite, reduces body's ability to absorb nutrients, and depletes important nutrients causing malnutrition (UN, 2004; Scrimshaw et al., 1968). The synergistic relationship between malnutrition and infectious disease worsen child health (Scrimshaw et al., 1968).

Another suggested method by which poor WASH impacts malnutrition is through environmental entropathy (EE), a subclinical disorder (Humphrey, 2009; Ngure et. al, 2014; Mbuya et al., 2016). According to Humphrey (2009), EE results from consumption of a large sum of fecal bacterial resulting from poor sanitation and hygiene. She proposed that the mechanism by which inadequate sanitation and hygiene leads to malnutrition is via EE rather than diarrhea (Humphrey, 2009; Ngure et. al, 2014). Another a study conducted in Bangladesh corroborates this hypothesis. The researchers found in clean households with adequate WASH had children with lower prevalence of chronic malnutrition and higher HAZ compared to those that did not. Furthermore, clean households environmental condition was also associated with lower EE prevalence. The authors hypothesize EE could be the cause of childhood stunting (Lin et al., 2013).

2.9 The effects of WASH on malnutrition

The impact of unclean water, sanitation, and hygiene on health has long been recognized. It has been reported that the greatest burden of health due to inadequate water and poor sanitation falls on children (Ngure et al., 2014). According to Pruss-Ustun and others (2008) an estimated 7 percent of the total burden of disease and 19 percent of child mortality is a consequence of poor WASH. More recently, using data from 193 countries, Cheng and colleagues (2012) explored and quantified the relationship between access to improved water and sanitation on infant, child, and maternal health outcomes. The results of this study found under-five mortality rate decreased by 1.14 death per 1000 live birth as access to improved water increased and rate decreased by 1.66 with increase in improved sanitation. The results also showed that increased access to improved water and sanitation were significantly associated with maternal mortality ratio. Furthermore, it has also been noted that poor water and sanitation results in different

Numerous studies have also investigated the impact water and sanitation with on malnutrition. An ecological study conducted by Spears et al. (2013) analyzed the relationship between open defecation and stunting using data from 112 districts of India. The researchers reported a 10 percent increase in open defecation was associated with 0.7 percent stunting and severe stunting (HAZ below -3 standard deviation from the reference median) adjusting for socioeconomic status, maternal education, and caloric consumption. The study result contributes to the growing evidence of the impact of open defecation on childhood stunting. However, the ecological nature of this study make subjects it to ecological fallacy; thus, further research using other study designs are needed to support the findings (Rah et al., 2015).

A recent study examined the relationship between access to improved WASH conditions and stunting in children in rural regions of India using three large survey datasets. The results of this study showed an association between household access to improved sanitation and stunting in children aged 0-23 months. After adjustment of potential confounders, the researchers found that children living in households with improved sanitation facility had 16-39 percent lower odds of being stunted compared to those with unimproved sanitation. Household with improved source of drinking water, however, was not associated with a HAZ. Additionally, the researchers reported the importance of hygiene on nutritional status. They found that children in household in which mother's/caregiver's reported washing their hands prior to a meal or after defecation had 14 percent lower risk of stunting compared to children in homes that did not. Furthermore, this study suggests that households improved source of drinking water and/or improved sanitation facility was available, stronger protective effect was observed between mother's/caregiver's hygienic practice and child stunting (Rah et al., 2013).

Corroborating Rah et al.'s (2013) finding, Esrey (1996) suggests improved sanitation plays a more critical role than improved water when considered independently. He reported that an incremental improvement of sanitation was associated with 0.06-0.65 increments in HAZ. On the contrary, an improvement in water supply was not associated with increased in HAZ; however, when improved sanitation and improved water were both present, a small increase in HAZ was observed. Similarly to finding for HAZ, weight-for-age also increased ranging from 0.095-0.344 with incremental increase in sanitation services. As previously observed with HAZ, Esrey reported that no association was observed between WAZ and water supply in the absence of improved sanitation. This study also suggested that there is synergistic effect between water and sanitation.

A recent case-control study conducted in Bangladesh examined the effect of households' environmental conditions on environmental enteropathy (EE) and growth among children age 4 and younger. The researchers found that children living in clean households environments where there was access to improved water supply, improved sanitation, and good hygiene had a 22 percent lower stunting prevalence and 0.54 (95% CI 0.06-1.01) higher HAZ compared to children living in households with unclean environments. Similar to Esrey's findings, this study also showed a presence of both improved water and sanitation was associated with the greatest gain in HAZ. The researchers did not find an association between household environmental conditions and wasting or underweight conditions (Lin et al., 2013).

A longitudinal study of 24-month-old Peruvian children conducted by Checkley et al. (2004) also supported the above findings. The study showed children living in households with worst condition of water supply and sanitation were 1.0 cm shorter than those living in households with the best conditions. The full benefits of improved water on child's health was only observed when the household also had access to improve sanitation and also had better water storage practices.

Unlike the study by Esrey (1996), Lin et al. (2013), and Checkley et al., (2004), a prospective cohort study conducted in Sudan by Merchant and colleagues (2003) did not find a synergistic effect of water and sanitation. Ngure et al. (2014) explains the discrepancy in these studies is potentially a result of varying hygienic conditions and practices of the environment of the children. The study, however, did revealed an association between household water and sanitation and the risk of stunting and reversal stunting among Sudanese children. The risk of stunting was the lowest among children residing in homes with access to both water and sanitation services compared to children from household without these facilities (multivariate RR = 0.79, 95% CI: 0.69–0.90). After adjusting for potential confounders, Merchant et al. (2003) reported that children from households with water and sanitation had a 17 percent greater likelihood of reversing stunting compared to children without either facility (Merchant et al., 2003).

Regional studies conducted in Ethiopia have also shown an association between water and sanitation on malnutrition. A study in the a food insecure region of Ethiopia compared the impact of four intervention groups (WASH, health programs, nutritional education, and the integration of all three interventions) with control group to determine which intervention could help reduce stunting in children between the ages of 6-36 months. Of all the intervention groups, only the WASH group showed a significant increase in the mean height-for-age Z-score, which showed a 12.1% decrease in the prevalence of stunting. Another study investigating the prevalence and predictors of undernutrition in Butajira, Ethiopia among children between the ages of 6-59 months showed childhood underweight status was associated with inadequate household sanitation facility (Medhin et al., 2010).

A country level study conducted Silva (2005) examined the effects of environmental factors, such as water and sanitation, on the probability of childhood stunting and being underweight using the 2000 EDHS. Her finding showed access to these services had a positive impact on child's height and weight.

The examined literature showed mixed results; some studies suggested that there is a joint effect of water and sanitation on malnutrition, while other studies suggested that the impact of water and sanitation are independent of each other (Merchant et al., 2003, Esrey, 1996, Lin et al., 2013). Furthermore, the results of these studies focused on stunting as an indicator of malnutrition, and many of the findings showed that the impact of water and sanitation is mainly associated with HAZ. The results of our study would add to the literature by investigating the impact of water and sanitation services on all three indictors of malnutrition. Furthermore, our study would contribute to the growing literature examining the impact of these services on child malnutrition in Ethiopia on a national scale. Finally, our study will also add to the literature by attempting decipher the combined effects of the water and sanitation services.

CHAPTER III

METHODOLOGY

3.1 Data Source

We performed secondary analysis using the most current round of the Demographic and Health Survey (DHS) for Ethiopia conducted in 2011. The DHS is an internationally representative household survey conducted in more than 90 countries. It is funded by the United States Agency for International Development (USAID) (EDHS, 2011). DHS collects national data on topics regarding health, nutritional status, fertility, family planning, childhood mortality and morbidity, HIV/AIDS knowledge, and maternal health. The Central Statistical Agency (CSA) conducted the Ethiopia Demographic and Health Survey (EDHS) with assistance from the Ministry of Health (MOH) (EDHS, 2011).

3.2 Sample design and participant observations

The Demographic and Health Survey employed a stratified two-stage cluster sampling method. The EDHS utilized the Population and Housing Census conducted in 2007 as the sampling frame. In stage one of the two-stage cluster sampling, 625 clusters were selected from the sampling frame (187 in urban areas and 437 in rural areas). These clusters were selected using systematic random sampling with probability of being selected in a cluster proportional to the size of the area. The second stage involved the selection of household from each of the 625 clusters based on a complete listing of households. Women ages 15-49 and men ages 15-59 in the households were eligible to participate in the survey.

Three questionnaires were used for EDHS data collection. The Household Questionnaires collected information about household characteristics such as source of drinking water, type of sanitation facilities, and socioeconomic characteristics. The Women's Questionnaires gathered information about reproductive history, knowledge about HIV/AIDS and STDS, fertility preferences, breastfeeding practices, and nutritional status. Furthermore, it collected data on height and weight measurements of eligible women and children under the age of five. Finally, the Men's Questionnaires also gathered similar information as the Women's Questionnaires (i.e. knowledge of HIV/AIDS and STDs, fertility preference); however, it did not collect detailed information about reproductive history. For this study, only the Household and the Women's dataset were utilized.

For the 2011 EDHS, a total of 17,817 households were selected, of which 17,018 were occupied. A total number of 16,702 households were successfully interviewed resulting in a 98% response rate (Central Statistical Agency (CSA) Ethiopia and ICF International, 2012). From the occupied household, 17,385 women were eligible to be interviewed, of which 16,515 completed the interview producing a response rate of 96%. Lastly, of the 15,908 men who were eligible for interview, 14,110 men were successfully interviewed (CSA Ethiopia and ICF International, 2012). Overall, both women and men in rural areas, compared to women and men living in urban areas, had a higher response rate. A detailed description of the survey design, data processing, and analysis can be located on the DHS website (CSA Ethiopia and ICF International, 2012).

Table 2 Sampling design

Household Interviews	Urban	Rural	Total
Households selected	5,518	12,299	17,817
Households found occupied[1]	5,272	11,746	17,018
Households interviewed	5,112	11,590	16,702
Response rate (%)[2]	97.0	98.7	98.1
Women's Interview ages 15-49			
Eligible women	5,656	11,729	17,385
Women interviewed	5,329	11,186	16,515
Response rate (%)[3]	94.2	95.4	95.0
Men's Interview ages 15-59			
Eligible men	5,062	10,846	15,908
Men interviewed	4,216	9,894	14,110
Response rate (%)[3]	83.3	91.2	88.7

Adapted from EDHS 2011 Final Report. [1]Household that that are occupied during data collection [2]Households interviewed/households occupied.[2]Respondents interviewed/eligible respondents

3.3 Study variables

3.3.1 Dependent variables

The primary dependent variable for this study is child malnutrition. Anthropometric measurements were collected by DHS for all children less than five years of age to calculate child growth indicators, which includes height-for-age, weight-for-height, and weight-for-age. These three indicators were used to determine children's nutritional status using the recommended 2006 WHO growth standard (WHO, 2006). The indicators are measured as standard deviation (SD) units away from the median of the WHO Child Growth Standards international reference population (WHO, 2006).

For this study, child malnutrition was determined using three indices: height-for-age Z-score (HAZ), weight-for-height Z-score (WHZ), and weight-for-age Z-score (WAZ). Each of these indices was categorized based on WHO established cut-off points (WHO, 2006). Children were considered stunted if their HAZ was less than -2 SD from the median of the standard reference, wasted if their WHZ was less than -2 SD from the median of the standard reference, and underweight if their WAZ was less than -2 SD from the median of the standard reference (WHO, 2006).

3.3.2 Independent Variables

There are two primary independent variables: source of drinking water and types of sanitation facility. Using the Joint Monitoring Program's definition, source of drinking water and sanitation facilities were categorized as improved or unimproved (WHO/UNICEF, 2014). Source of drinking water was classified as "Improved" if it was obtained from the following; piped water into a dwelling or plot/yard, protected well or spring, tube well/borehole, public tab/standpipe and rainwater. Drinking water was categorized as "Unimproved" if was obtained from the following sources; unprotected dug well and spring, cart with small tank/drum, tanker truck, and surface water. Bottled water was classified as improved only if the participant's non-drinking source of water was piped in the dwelling or yard; otherwise, bottle water was classified as "Unimproved".

For this analysis, the following toilet facilities were classified as "Improved" sanitation facilities: flush to toilet, piped sewer system, septic tank, pit latrine with slab, VIP latrines, and composting toilets. However, if any of the sanitation facilities that were considered "Improved" were also shared between two or more households, then they were classified as "Unimproved". Furthermore, other sanitation facilities (i.e. bucket toilets, hanging toilets/latrine, bush/field) were grouped as "Unimproved" type of sanitation.

For the purpose of examining our third hypothesis, additional categorical groups of water and sanitation services were created: group 1: "Improved" water and "Improved" sanitation; group 2, "Improved" water and "Unimproved" sanitation; group 3, "Unimproved" water and "Improved" sanitation; and group 4, "Unimproved" water and "Unimproved" sanitation.

Based on literature findings, covariates related to the children, mothers, and household were explored as potential confounder for this study. The children variables included child's age, gender, size at birth, recent diarrheal episode, and fever. Child's age, defined in months, was categorized into six age groups. Size of the child at birth was reported subjectively by the respondent and was reclassified as small, average, and large. Participants were asked if children experienced any episodes of diarrhea in the last 24 hours prior to the interview. Information about fever in children was collected by asking respondents whether the child had fever two weeks prior to the interview. Maternal variables include age and education level. The mother's education level was categorized as no education, primary education, and higher education level.

Education is an important variable that has been shown in literature to be significantly associated with child health (Silva, 2005).

Household variables included type of place of residence (urban/rural), wealth index, household size, and number of children less than five years of age. Similar to the study conducted by Silva (2005), women's body mass index (BMI) was used in this study as a proxy for household food availability. BMI below 18.5 was considered as indicator of household food insecurity. This variable was dichotomized taking a value of 1 if the maternal BMI was below18.5. Additionally, treatment of water, time to get water and disposal of child's feces were included as household variables. Time to get water measures the round trip time (0-360 minutes) traveled by participants to collect water. This continuous variable was dichotomized as having a trip time of 30 minutes or less and traveling time more than 30 minutes. Participants who reported as having water source on the premise were classified as having a trip time of 30 minutes or less. "Don't know" responses were classified as missing. Respondent with children under five living with them were asked the method used to dispose youngest child's stool; the responses were categorized as "Safe" or "Unsafe". Disposal of feces was classified as "Safe" if the child is helped to use a toilet or latrine or fecal matter is disposed into a toilet or latrine. All other methods were considered "Unsafe" (Bain, et al, 2015).

3.4 Data analysis

Data management and statistical analysis for this study was carried out using Statistical Analysis System (SAS) software version 9.3. Data from EDHS Household Member Questionnaire and Children Questionnaire were merged using "Cluster number", "Household number", "Respondent's line number", and "Child's line number in the household". Sample weight was used in all of the study analysis to make data results representative of the entire country's population.

Descriptive statistical analysis was performed to examine the frequency distribution of the study's primary independent variables (sanitation and water), dependent variables (childhood stunting, wasting, and underweight), and all other variables included in the study. Bivariate analysis was conducted using logistic regression to measure the degree of association between stunting, wasting, and being underweight and different independent variables. Odds ratios, 95% confidence limits, and p-value were calculated for the analysis. A p-value less than 0.05 was considered statistically significant.

Finally, multivariate logistic regression analysis was performed to control for potential confounders while examining the relationship between the primary independent and dependent variable. Only variables that showed significant association ($p\text{-value}<0.05$) with each dependent variable in the bivariate analysis were selected and adjusted for in the multivariate analysis. The association between the independent variables and dependent variables were assessed by calculating odd ratios and 95% CL. Statistical association was significant if the p-value was less than 0.05.

We formulated several models in this study. In the first three models, improved water and improved sanitation were used as the reference group. The regression analyses were performed separately for each dependent and independent variable. The first model predicts the probability of stunting, wasting, and being underweight as a function of water and sanitation as the exposure of interest adjusting for children characteristics (i.e. gender, age, and birth weight). The second model and third models examine the association between the dependent and independent variables by additionally including maternal characteristics (i.e. education level, age) and household characteristics (i.e. place of residence, wealth index, household disposal of child stool) as covariates.

In addition to examining the individual effects of households' access to water and sanitation on childhood malnutrition, we were also interested in examining the synergistic association between the two services. In our fourth model, adjusting for child characteristics, we used the logistic regression analysis to predict the probability of stunting, wasting, and being underweight as a function of the four different groups of water and sanitation services described. We repeated this step for model 5 and model 6, but also included maternal characteristics (for model 5); for model 6 we controlled for child, maternal, and household characteristics. The reference category for these three models was improved water and improved sanitation (group 1).

CHAPTER IV

RESULTS

As previously stated, the purpose of this study was to examine the association between access to water and sanitation and malnutrition in Ethiopian children under-five years of age. The weighted bivariate analysis results for the three indicators of malnutrition employed in this study, stunting, wasting, and underweight, are presented separately. Child malnutrition is caused by a number of interrelated factors; as a result, we used multivariate regression to assess the relationship between drinking water and sanitation facility and the probability of child malnutrition while controlling for potential confounding variables.

4.1 Descriptive analysis

After merging the Household Member and Children dataset, there were a total of 11,654 observations. After excluding children for whom anthropometric indicators were missing, the sample sized decreased to 9,611. Table 2 depicts the weighted descriptive statistic for children, mothers, and households. As shown on the table, the ages of the children ranged from 0-59 months with the majority of the children falling in the 36 - 37 age group. About half of the children in the study sample were male (51.3 percent). It was reported that the majority of the children, 38.9 percent, were average weight at birth. Approximately 44 percent of the children under-five years of age were stunted having a HAZ below -2SD. Approximately 10 percent and 29 percent of children were wasted and underweight, respectively.

Examining educational attainment, 6696 (69 percent) of women had no education, and only 1.4 percent of the women had higher education. The age of the women ranged from 15-49 years; 51.9 percent (4915) of the women were between 20 and 29 years of age. About 21percent (2575) had BMI below 18.5.

As for socioeconomic status and household living environment, more than 44 percent of respondents were poor, 20.8 percent were middle class, and 34.3 percent were rich. About 65 percent of the household had between two to three children under five years old in the household, and 52.4 percent had a household size between four to six members. The round trip time to collect water for 41.3 percent of the respondent is greater than 30 minutes. The majority, 85.5 percent (816), of the households adequately treats their drink water. About 54 percent of the study population used unimproved source of drinking water and about 82 percent used unimproved sanitation facility. A total number of 6245 (64.6 percent) households do not practice safe stool disposal.

Table 3 Demographic and descriptive statistics of the study population

Variables	**N (%)**
Stunted N (%)	
Yes	4091 (44.5)
No	5520 (55.5)
Wasted N (%)	
Yes	1136 (9.9)
No	8475 (90.1)
Underweight N (%)	
Yes	2902 (29.0)
No	6709 (90.1)
Child's gender N (%)	
Female	4721 (48.7)
Male	4890 (51.3)
Child's age (months) N (%)	
<6	1001 (10.4)
6-11	967 (10.4)
12-23	1776 (18.1)
24-35	1878 (18.7)
36-47	2055 (22.0)
48-59	1934 (20.4)
Child's size at birth N (%)	
Small	3019 (29.7)
Average	3794 (38.9)
Large	2772 (31.4)
Mother's age N (%)	
15-19	393 (3.8)
20-29	4915 (51.9)
30-39	3484 (35.3)
≥40	819 (9.0)
Mother's education N (%)	
No education	6696 (69.2)
Primary	2448 (27.2)
Secondary	308 (2.2)
Higher	159 (1.4)
Women's BMI N (%)	
< 18.5	2575 (21.4)
≥18.5	7036 (78.5)
Place of residence N (%)	
Rural	8066 (87.5)
Urban	1545 (12.5)
Household size N (%)	
<4	960 (9.1)
4-6	4855 (52.4)
7-9	3027 (31.8)
>10	769 (6.7)

Variables	N (%)
Children under 5 in household N (%)	
0-1	3206 (33.6)
2-3	6144 (64.7)
≥4	261 (1.8)
Wealth index N (%)	
Poor	4737 (44.7)
Middle	1592 (20.9)
Rich	3282 (34.4)
Diarrhea (in the past 24 hours) N (%)	
Yes	1498 (13.7)
No	8098 (86.3)
Fever (in the past 2 weeks) N (%)	
Yes	1916 (17.5)
No	7663 (82.5)
Disposal of child stool N (%)	
Safe disposal	2942 (35.5)
Unsafe disposal	6245 (64.6)
Time to get water N (%)	
≤ 30 minutes	5562 (58.7)
> 30 minutes	4049 (41.3)
Treatment of water N (%)	
Adequate	816 (85.5)
Inadequate treatment	89 (14.6)
Source of drinking water N (%)	
Improved	4837 (46.3)
Unimproved	4774 (53.7)
Type of sanitation facility N (%)	
Improved	793 (18.0)
Unimproved	2320 (82.0)

4.2 Bivariate analysis

4.2.1 Stunted

As shown in Table 3, stunting was significantly associated with child's gender, age, child's size at birth, mother's education, wealth index, disposal of child stool, source of drinking water, and place of residence. The results showed that the odds of stunting in children under-five years of age was higher amongst boys (OR: 1.2; 95% CL 1.1-1.3) compared to girls. Stunting was also associated with child's age; children between 24 to 35 months had a greater odds of being stunted (OR: 12.6; CL 8.9-17.7) compared to children who were less than 6 months old. Compared to children small at births the odds of stunting in children that were average size at birth was lower (OR: 0.7; 95% CL 0.7-0.9). The mother's education was significantly associated with child's likelihood of stunting. Compared to children with mothers who had no education, mothers with an increased level of education was associated with lower odds of stunting.

The study showed that children living in urban regions had a 0.5 (95% CL 0.4-0.7) reduced odds of stunting compared to their counterparts living in rural areas. The odds of stunting was lower in children with an increased number of children under five years old in the household. Children from rich household were less likely to be stunted compared to children belonging to poor households, and this difference is statistically significant (OR: 0.7; 95% CL 0.6-0.8). The odds of stunting was significantly higher amongst children living in households where stool of children younger than five years old was disposed in an unsafe compared to those living in households where safe disposal is practiced (OR: 1.2; 95% CL 1.1-1.4).

In terms of access to drinking water, children living in households with access to unimproved source of drinking water had 1.2 odds of stunting compared to children in household with access to improved drinking water source. Children residing in households with access to unimproved sanitation facility had 1.3 increased odds of stunting compared to children living in household with access to improved sanitation facility.

Table 4 Bivariate analysis of the association between **stunting** and independent variables

Variables	Unadjusted OR	95% CL	p-Value
Child's gender N (%)			
Female	1.0	Reference	Reference
Male	1.2	1.1-1.3	0.02*
Child's age (months) N (%)			
<6	1.0	Reference	Reference
6-11	2.5	1.7-3.8	<0.01*
12-23	7.5	5.3-10.6	<0.01*
24-35	12.6	8.9-17.7	<0.01*
36-47	11.4	7.9-16.3	<0.01*
48-59	8.8	6.2-12.5	<0.01*
Child's size at birth N (%)			
Small	1.0	Reference	Reference
Average	0.7	0.7-0.9	<0.01*
Large	0.7	0.6-0.8	<0.01*
Mother's age N (%)			
15-19	1.0	Reference	Reference
20-29	1.2	0.9- 1.6	0.35
30-39	1.3	0.9- 1.7	0.12
≥40	1.4	1.0- 2.0	0.08
Mother's education N (%)			
No education	1.0	Reference	Reference
Primary	0.8	0.2- 0.5	<0.01*
Secondary	0.3	0.7- 0.9	<0.01*
Higher	0.3	0.2- 0.5	<0.01*
Women's BMI N (%)			
< 18.5	1.1	1.0-1.3	0.07
≥18.5	1.0	Reference	Reference
Place of residence N (%)			
Rural	1.0	Reference	Reference
Urban	0.5	0.4-0.7	<0.01*
Household size N (%)			
<4	1.0	Reference	Reference
4-6	1.1	0.9- 1.4	0.29
7-9	1.1	0.9- 1.4	0.46
>10	1.0	0.7-1.3	0.91
Children under 5 in household N (%)			
0-1	1.0	Reference	Reference
2-3	0.9	0.8-1.1	0.22
≥4	0.6	0.3- 1.1	0.08
Wealth index N (%)			
Poor	1.0	Reference	Reference
Middle	0.9	0.8- 1.1	0.31
Rich	0.7	0.6- 0.8	<0.01*

Variables	Unadjusted OR	95% CL	p-Value
Diarrhea (in the past 24 hours) N (%)			
Yes	1.1	0.9-1.2	0.45
No	1.0	Reference	Reference
Fever (in the past 2 weeks) N (%)			
Yes	0.9	0.8- 1.0	0.11
No	1.0	Reference	Reference
Disposal of child stool N (%)			
Safe disposal	1.0	Reference	Reference
Unsafe disposal	1.2	1.1-1.4	0.01*
Time to get water N (%)			
≤ 30 minutes	1.0	Reference	Reference
> 30 minutes	1.1	0.9-1.2	0.37
Treatment of water N (%)			
Adequate	1.0	Reference	Reference
Inadequate treatment	1.4	0.8-2.6	0.29
Source of drinking water N (%)			
Improved	1.0	Reference	Reference
Unimproved	1.2	1.0-1.3[a]	0.03*
Type of sanitation facility N (%)			
Improved	1.0	Reference	Reference
Unimproved	1.3	1.0-1.7[b]	0.04*

**Statistically significant at 0.05 level; CL=confidence limit; [a,b] the lower limit of the CL before rounding was 1.02*

4.2.2 Wasted

Table 4 shows the relationship between wasting and different independent variables. Stunting was significantly associated with child's gender, age, child's size at birth, mother' educational level, women's BMI, place of residence, wealth index, diarrhea, fever, disposal of child's stool, and time to get water.

In the study sample, boys had a 1.4 time increased odds of wasting compared to girls. Children ages between of 24 to 35, 36 to 47, and 48 to 59 months were less likely to be wasted compared to those younger than 6 months (OR: 0.6; 95% CL 0.4-0.9; OR: 0.4; 95% CL 0.3-0.6; and OR: 0.5; 95% CL 0.3-0.7, respectively). Children that were average (OR: 0.6; 95% CL 0.5-0.7) and large size at birth (OR: 0.5; 95% CL 0.4-0.7) were less likely to be wasted than children that were small size. Wasting was significantly associated with primary and secondary level maternal education (OR: 0.7; 95% CL 0.1-0.7 and OR: 0.3; 95% CL 0.6-0.9, correspondingly). Children with mothers age 20-29 years and 40 years or older had lower odds of wasting compared to children with mothers between 15 to 19 years.

The table depicts that children who had diarrhea 24 hours before the interview were significantly more likely to be wasted compared to those who did not (OR: 1.9; 95% CL 1.6-2.4). Those who had fever within two weeks before the interview also had significantly higher odds of wasting compared to children who did not (OR: 1.9; 95% CL 1.6-2.4). Children residing in urban areas had 50 percent lower odds of wasting compared to children living in rural settings (95% CL 0.4-0.7).

Women with BMI less than 18.5 were significantly less likely to have children who were wasted (OR: 1.9; 95% CL 1.6-2.3). Wealth index was significantly associated with reduced odds of wasting; those in rich households had a 50 percent decreased odds of wasting compared to children in poor households.

The odds of wasting was significantly higher amongst children in households where stool of children younger than five years was disposed in an unsafe manner compared to those residing in household where stool was safely disposed (OR: 1.6; 95% CL 1.3-2.0). Children belonging to home with where respondent reported traveling more than 30 minutes to collect water were more significantly wasted than children in homes where time to collect water was 30 minutes of less (OR: 1.3; 95% CL 1.1-1.6). As shown in the table, household's access unimproved source of drinking water was not associated with childhood wasting (OR: 1.0; 95% CL 0.8-1.3). On the other hand, the odds of wasting among children living in households with access to unimproved sanitation was 1.6 times the odd of wasting among children living in household with access to improved sanitation facility; however, this relationship is not statistically significant (95% CL 1.0-2.4).

Table 5 Bivariate analysis of the association between **wasting** and independent variables

Variables	Unadjusted OR	95% CL	p-Value
Child's gender N (%)			
Female	1.0	Reference	Reference
Male	1.4	1.3-1.7	<0.01*
Child's age (months) N (%)			
<6	1.0	Reference	Reference
6-11	1.3	0.9-1.9	0.16
12-23	1.0	0.7-1.5	0.79
24-35	0.6	0.4-0.9	<0.01*
36-47	0.4	0.3-0.6	<0.01*
48-59	0.5	0.3-0.7	<0.01*
Child's size at birth N (%)			
Small	1.0	Reference	Reference
Average	0.6	0.5-0.7	<0.01*
Large	0.6	0.4-0.7	<0.01*
Mother's age N (%)			
15-19	1.0	Reference	Reference
20-29	0.8	0.5- 1.3	0.43
30-39	0.8	0.5-1.2	0.26
≥40	0.9	0.5-1.4	0.56
Mother's education N (%)			
No education	1.0	Reference	Reference
Primary	0.7	0.1-0.7	<0.01*
Secondary	0.3	0.6-0.9	<0.01*
Higher	0.4	0.2-1.2	0.10
Women's BMI N (%)			
< 18.5	1.9	1.6-2.3	<0.01*
≥18.5	1.0	Reference	Reference
Place of residence N (%)			
Rural	1.0	Reference	Reference
Urban	0.5	0.4-0.7	<0.01*
Household size N (%)			
<4	1.0	Reference	Reference
4-6	0.9	0.6- 1.2	0.35
7-9	0.9	0.6- 1.3	0.44
>10	1.0	0.6- 1.5	0.85
Children under 5 in household N (%)			
0-1	1.0	Reference	Reference
2-3	1.1	0.9-1.3	0.67
≥4	1.5	0.7-3.0	0.31
Wealth index N (%)			
Poor	1.0	Reference	Reference
Middle	0.7	0.6-1.0	0.03*
Rich	0.5	0.4-0.6	<0.01*

Variables	Unadjusted OR	95% CL	p-Value
Diarrhea (in the past 24 hours) N (%)			
Yes	1.9	1.6-2.4	<0.01*
No	1.0	Reference	Reference
Fever (in the past 2 weeks) N (%)			
Yes	1.9	1.6-2.4	<0.01*
No	1.0	Reference	Reference
Disposal of child stool N (%)			
Safe disposal	1.0	Reference	Reference
Unsafe disposal	1.6	1.3-2.0	0.01*
Time to get water N (%)			
≤ 30 minutes	1.0	Reference	Reference
> 30 minutes	1.3	1.1-1.6	0.02*
Treatment of water N (%)			
Adequate	1.0	Reference	Reference
Inadequate treatment	1.3	0.5-3.1	0.64
Source of drinking water N (%)			
Improved	1.0	Reference	Reference
Unimproved	1.0	0.8-1.3	0.88
Type of sanitation facility N (%)			
Improved	1.0	Reference	Reference
Unimproved	1.6	1.0-2.4	0.06

**Statistically significant at 0.05 level; CL=confidence limit*

4.2.2 Underweight

Factors such as sex of the child, age, size of child at birth, place of residence, whether the child had diarrhea or not, wealth status of the household, mother's education, household food insecurity, whether or not the child had fever or not, disposal of child's stool, and type of sanitation facility were significantly associated with child underweight status (Table 5).

Male children compared to female children were 19 percent more likely to be underweight. The odds of underweight increased with child's age from 6-35 months and then slightly decreased between 36-59 months. Children aged 25-35 months had the greatest odds of being underweight compared to children aged less than 6 months (OR: 4.5; 95% CL 3.3-6.3). Children that were large at birth were less likely to underweight compared to those born small. The children that had diarrhea 24 hours prior to the interview had 1.4 odds of being underweight compared to those who did not (95% CL 1.2-1.7). Similarly, children who had fever two weeks prior to the interview were 39 percent more likely to be underweight compared to those who did not. Children whose mother had higher education had a 71 percent lower odds of being underweight compared to their counterparts who had no education (95% CL 0.1-0.6). Residing in urban regions was a protective factor against underweight (OR: 0.5; 95%; CL 0.3-0.7).

As shown in the table, increased household wealth status was significantly associated with decreased underweight status; the odds of a children being underweight living in rich households was 0.5 times (95% CL 0.4-0.6) that of children living in poor households. Unsafe disposal of child's stool was significantly associated with 44 percent increased likelihood of a child being underweight. The odds of being underweight among children living in households with access to unimproved source of drinking water was associated with 1.2 times (95% CL 1.0-1.4) that of children living in households with access to improved source of drinking water.

Unimproved sanitation facility was significantly associated with underweight status; compared to children in households with access to improved sanitation facilities, those with unimproved facilities had 1.2 increased odds of a being underweight compared to children living in household with access to improved sanitation facility (95% CL 0.5-0.9).

Table 6 Bivariate analysis of the association between **underweight** and independent variables

Variables	**Unadjusted OR**	**95% CL**	**p-Value**
Child's gender N (%)			
Female	1.0	Reference	Reference
Male	1.2	1.1-1.3	<0.01*
Child's age (months) N (%)			
<6	1.0	Reference	Reference
6-11	2.3	1.7-3.3	<0.01*
12-23	3.8	2.7-2.3	<0.01*
24-35	4.5	3.3-6.3	<0.01*
36-47	4.4	3.2-6.1	<0.01*
48-59	4.2	3.0-5.8	<0.01*
Child's size at birth N (%)			
Small	1.0	Reference	Reference
Average	0.6	0.5-0.7	<0.01*
Large	0.5	0.4-0.6	<0.01*
Mother's age N (%)			
15-19	1.0	Reference	Reference
20-29	1.0	0.7-1.5	0.90
30-39	1.1	0.8-1.6	0.67
≥40	1.3	0.9-1.8	0.24
Mother's education N (%)			
No education	1.0	Reference	Reference
Primary	0.1	0.03-0.3	<0.01*
Secondary	0.8	0.6-0.9	<0.01*
Higher	0.3	0.1-0.6	<0.01*
Women's BMI N (%)			
< 18.5	1.8	1.5-2.1	<0.01*
≥18.5	1.0	Reference	Reference
Place of residence N (%)			
Rural	1.0	Reference	Reference
Urban	0.5	0.3-0.7	<0.01*
Household size N (%)			
<4	1.0	Reference	Reference
4-6	1.2	1.0-1.5	0.14
7-9	1.1	0.9-1.4	0.52
>10	1.0	0.7-1.4	0.97
Children under 5 in household N (%)			
0-1	1.0	Reference	Reference
2-3	0.9	0.8-1.0	0.13
≥4	1.0	0.6-1.8	0.96
Wealth index N (%)			
Poor	1.0	Reference	Reference
Middle	0.8	0.7-1.1	0.02*
Rich	0.5	0.4-0.6	<0.01*

Variables	**Unadjusted OR**	**95% CL**	**p-Value**
Diarrhea (in the past 24 hours) N (%)			
Yes	1.4	1.2-1.7	<0.01*
No	1.0	Reference	Reference
Fever (in the past 2 weeks) N (%)			
Yes	1.4	1.2-1.6	<0.01*
No	1.0	Reference	Reference
Disposal of child stool N (%)			
Safe disposal	1.0	Reference	Reference
Unsafe disposal	1.4	1.2-1.7	<0.01*
Time to get water N (%)			
≤ 30 minutes	1.0	Reference	Reference
> 30 minutes	1.6	1.0-1.4	0.07
Treatment of water N (%)			
Adequate	1.0	Reference	Reference
Inadequate treatment	1.4	0.7-2.5	0.34
Source of drinking water N (%)			
Improved	1.0	Reference	Reference
Unimproved	1.2	1.0-1.4	0.06
Type of sanitation facility N (%)			
Improved	1.0	Reference	Reference
Unimproved	1.5	1.1-2.1	0.01*

**Statistically significant at 0.05 level; CL=confidence limit*

4.3 Multivariate analysis

4.3.1 Stunted

Our first model examined the association between source of drinking water and sanitation facility and childhood stunting adjusting for child's gender, age, and size at birth. Household access to unimproved source of drinking water was not a predictor of child stunting. Stunting among children living in household with access to unimproved sanitation was 1.4 times (95% CL 1.1-1.9) the odds of stunting among children living in household with access to improved source of drinking water

For model 2, in addition to the variables adjusted for in in the first model, we also controlled for maternal education. Household access to source of drinking water was still not a predictor of stunting. After adjusting for the child and maternal characteristics, household access to unimproved sanitation was no longer significantly associated with childhood stunting (AOR: 1.3; 95% CL 1.1-1.7). The final model, model 3, controlled for all the confounding variables included in model 1 and model 2 as well as place of residence, wealth index, and stool disposal. Having access to unimproved source of drinking water was was associated with stunting (AOR: 1.0; 95% CL 0.8-1.2). Similarly, household access to unimproved sanitation facility was not a predictor of stunting (AOR: 1.1; 95% CL 0.8-1.5).

4.3.2 Wasted

In model 1, we adjusted for child's age, gender, childhood diarrhea, and fever, and size at birth to examine the relationship between unimproved source of drinking water and sanitation and wasting. After controlling for these variables, unimproved water was not associated with wasting (OR: 1.0 95% CL 0.8-1.2). On the other hand, unimproved sanitation facility was associated with wasting although it was not statically significant (AOR: 1.7; 95% 1.1-2.4). After controlling for all child and maternal characteristics, in our second model, unimproved sanitation and unimproved source of drinking water were l not significantly associated with the outcome.

Model 3 controlled BMI, place of residence, wealth index, stool disposal, and time to get wanted in addition to the confounding variables used in model 1 and model 2. After adjustments of these variables, unimproved sanitation was still not a predictor of wasting. Surprisingly, children living in household with unimproved source of drinking water had lower odds of wasting compared to those living in household with improved source of drinking water (AOR: 0.7; 95% CL 0.6-0.9).

4.3.3 Underweight

In model 1 we controlled for children characteristics, such as gender, sex, birth size, current diarrhea, and fever. Unimproved source of sanitation facilities was significantly associated with underweight status in children (AOR: 1.6; 95% CL 1.2-2.2). Children in household with access to unimproved water, adjusting for children characteristics, had 1.2 greater odds of being underweight compared to those living in households with access to improved source of drinking water (AOR: 1.2; 95% CL 1.0-1.4). Model 2 adjusted for maternal education in addition to the variables in model 1. Households' access to unimproved sanitation services was statistically associated with 1.5 higher odds of childhood underweight (95% CL 0.5-0.9). Household access to unimproved source of drinking water was no longer a predictor of child underweight status after adjusting for these variables.

The final model, model 3, adds all of the confounding variables from model 1 and model 2, and controls for household and environmental factors like, place of residence, wealth index, and stool disposal also. In this model, unimproved sanitation was still significantly associated with child underweight. Compared to children living in homes with access to improved sanitation facility, children living in household with unimproved sanitation facility had 1.4 increased odds of being underweight (95% CL 1.1-1.9). After adjusting for all confounding variable, living in household with unimproved source of drinking water showed to be protective in this model (AOR: 0.9; 95%CL0.7-1.1).

Table 7 Multivariate logistic regression analysis of the associations between access to sanitation and water and childhood malnutrition indices

	Model 1 Child characteristics			**Model 2 Child and maternal characteristics**			**Model 3 Child, maternal, and household characteristics**		
Variable	**N**	**AOR (95%CL)**	**p-value**	**N**	**AOR (95%CL)**	**p-value**	**N**	**AOR (95%CL)**	**p-value**
Stunted [1]									
Source of drinking water									
Improved	9585	1.0	Ref	9585	1.0	Ref	9611	1.0	Ref
Unimproved		1.2 (1.0-1.4)	0.01*		1.1 (1.0-1.3)	0.14		1.0 (0.8-1.2)	0.86
Type of sanitation facility									
Improved	3106	1.0	Ref	3106	1.0	Ref	2980	1.0	Ref
Unimproved		1.4 (1.1-1.9)	<0.01*		1.3 (1.0-1.7)	0.08		1.1 (0.8-1.5)	0.67
Wasted [2]									
Source of drinking water									
Improved	9552	1.0	Ref	9552	1.0	Ref	9133	1.0	Ref
Unimproved		1.0 (0.8-1.2)	0.96		0.9 (0.7-1.2)	0.49		0.7 (0.6-0.9)	0.01*
Type of sanitation facility	3095								
Improved		1.00	Ref	3095	1.0	Ref	2980	1.0	Ref
Unimproved		1.7 (1.1-2.4)	0.04*		1.5 (1.0-2.4)	0.07		1.4 (0.9-2.3)	0.14
Underweight [3]									
Source of drinking water									
Improved	9552	1.0	Ref	9552	1.0	Ref	9133	1.0	Ref
Unimproved		1.2 (1.0-1.4)	0.05		1.1 (0.9-1.3)	0.26		0.9 (0.7-1.1)	0.38
Type of sanitation facility									
Improved	3095	1.0	Ref	3095	1.0	Ref	2980	1.0	Ref
Unimproved		1.6 (1.2-2.2)	<0.01*		1.5 (1.1-2.0)	0.01*		1.4 (1.1-1.9)	0.04*

**Statistically significant at 0.05 level; AOR= adjusted odds ratio; CL=confidence limit; Ref=reference group*
*[1]**Stunted**: Model 1 adjusted for child's gender, child's age, and child's size at birth*
Model 2, in addition to variable in model 1, model 2 adjusted for mother's education level
Model 3 adjusted for variables in model 1 and 2 in addition to place of residence, wealth index, and stool disposal.
*[2]**Wasted**: Model 1 adjusted for child's gender, child's age, child's size at birth, diarrhea (in the past two weeks) and fever (in the past two weeks).*
Model 2 adjusted for all variables in model one plus mother's education level
Model 3 adjusted variables in model 1 and 2 in addition to BMI, place of residence, wealth index, stool disposal, and time to get water
*[3]**Underweight**: Model 1 adjusted for child's gender, child's age, child's size at birth, diarrhea (in the past two weeks) and fever (in the past two weeks)*
Model 2 adjusted for variable in model 1 plus mother's education level
Model 3 adjusted for all variables in model 1 and 2 plus place of residence, wealth index, and stool disposal

4.3.4 Synergistic association

Children from households without access to both improved water and sanitation had increased odds of stunting. Adjusting for child characteristics, children from households with access to improve water and unimproved sanitation had 1.6 greater odds (95% CL 1.2-2.30) of stunting compared to children from home with access to improved water and sanitation. Children from households with without access to both services had 1.6(1.1-2.3) increased odds of stunting compared to children from home with access to improved water and sanitation. After adjusting for maternal characteristics, access to improved water and unimproved sanitation still showed to be statistically associated with stunting (AOR 1.5; 95% CL 1.1-2.1). After adjusting for all variables, there were no statistically significant associations between any of the four levels of water and sanitation groups and stunting.

The odds of wasting among children from households with access to improved water and unimproved sanitation was 2.3 times (95% CL 1.3-4.3) the odds of wasting in children from households with both improved water and sanitation, controlling for child characteristics. The odds of wasting among children from household with improved water and unimproved sanitation remained statistically significant after adjusting for maternal characteristic (AOR 2.2 95% CL 1.2-4.1) and (AOR 2.0; 95% CL 1.1-3.9) after adjusting for child, maternal, and household characteristics.

Children from households without access to both improved water and sanitation had increased odds of being underweight. Adjusting for child characteristics, children from households with access to improve water and unimproved sanitation had 2.4 higher odds (95% CL 1.6-3.6) of being underweight compared to children from households with access to improved water and sanitation. Children from households with without access to both services had 2.4(1.4-4.1) increased odds of being underweight compared to children from home with access to improved water and sanitation. After adjusting for maternal characteristics, the odds of being underweight was greater for children from households with either between improved water and unimproved sanitation (AOR 2.1; 95% CL 1.4-3.3), or unimproved water and improved sanitation (AOR 2.1; 95% CL 1.2-3.6), or unimproved water and sanitation (AOR 2.0; 95% CL 1.3-3.0) compared to those from home with improved water and sanitation. Children from home with access to improved water and unimproved sanitation still showed to be statistically associated with underweight status (AOR 1.9; 95% CL 1.2-3.0).

Table 8 Multivariate logistic regression analysis of the association between water and sanitation groups and childhood malnutrition indices

	Model 4 Child characteristics N=3095[a]		Model 5 Child and maternal characteristics N=3095[b]		Model 6 Child, maternal, and household characteristics N=2980[c]	
Variable	**AOR (95%CL)**	**p-value**	**AOR (95%CL)**	**p-value**	**AOR (95%CL)**	**p-value**
Stunted[1]						
Types of services						
Improved water & improved sanitation	1.0	Ref	1.0	Ref	1.0	Ref
Improved water & unimproved sanitation	1.6 (1.2-2.3)	<0.01*	1.5 (1.1-2.1)	0.04*	1.1 (0.8-1.7)	0.55
Unimproved water & improved sanitation	1.5 (0.9-2.4)	0.15	1.3 (0.7-2.1)	0.40	0.9 (0.5-1.6)	0.69
Unimproved water & unimproved sanitation	1.6 (1.1-2.3)	0.01*	1.4 (1.0-1.5)	0.09	0.9 (0.6-1.4)	0.70
Wasted[2]						
Types of services						
Improved water & improved sanitation	1.0	Ref	1.0	Ref	1.0	Ref
Improved water & unimproved sanitation	2.3 (1.3-4.3)	<0.01*	2.2 (1.2-4.1)	0.01*	2.0 (1.1-3.9)	0.03*
Unimproved water & improved sanitation	1.8 (0.8-4.2)	0.14	1.6 (0.7-3.8)	0.27	1.1 (0.4-2.8)	0.81
Unimproved water & unimproved sanitation	1.8 (1.0-3.1)	0.05	1.6 (0.9-2.9)	0.13	1.1 (0.6-2.1)	0.74
Underweight[3]						
Types of services						
Improved water & improved sanitation	1.0	Ref	1.0	Ref	1.0	Ref
Improved water & unimproved sanitation	2.4 (1.6-3.6)	<0.01*	2.1 (1.4-3.3)	<0.01*	1.9 (1.2-3.0)	<0.01*
Unimproved water & improved sanitation	2.4 (1.4-4.1)	<0.01*	2.1 (1.2-3.6)	<0.01*	1.5 (0.9-2.6)	0.13
Unimproved water & unimproved sanitation	2.3 (1.5-3.3)	<0.01*	2.0 (1.3-3.0)	0.01*	1.5 (1.0-2.2)	0.08

**Statistically significant at 0.05 level; AOR= adjusted odds ratio; CL=confidence limit; Ref=reference group. For stunting model 1 N=3106[a], model 2 N=3106[b] and model 3 N=2980[c]*
[1]***Stunted**: Model 1 adjusted for child's gender, child's age, and child's size at birth*
Model 2, in addition to variable in model 1, model 2 adjusted for mother's education level
Model 3 adjusted for variables in model 1 and 2 in addition to place of residence, wealth index, and stool disposal.
[2]***Wasted**: Model 1 adjusted for child's gender, child's age, child's size at birth, diarrhea (in the past two weeks) and fever (in the past two weeks).*
Model 2 adjusted for all variables in model one plus mother's education level
Model 3 adjusted variables in model 1 and 2 in addition to BMI, place of residence, wealth index, stool disposal, and time to get water
[3]***Underweight**: Model 1 adjusted for child's gender, child's age, child's size at birth, diarrhea (in the past two weeks) and fever (in the past two weeks)*
Model 2 adjusted for variable in model 1 plus mother's education level
Model 3 adjusted for all variables in model 1 and 2 plus place of residence, wealth index, and stool disposal

CHAPTER V

DISCUSSION AND CONCLUSION

5.1 Discussion of results

5.1.1 Predictors of poor nutritional outcome

The purpose of this study was to investigate the relationship between household access to water and sanitation and childhood nutritional status. We used Ethiopia using data from 2011 EDHS, which is a nationally representative data.

The prevalence of stunting, wasting, and underweight was 44.5%, 9.9%, and 29.0%, respectively. According to the WHO's classification, when the prevalence of stunting, wasting, and underweight are greater than 40%, 30%, and 15%, respectively, it is considered "very high" or "critical" (de Onis et al., 1997). Hence, as reflected by the proportion of Ethiopian children who are malnourished, it is evident that the levels in the country are very high.

In our study, nutritional status varied by sex. Boys were more likely to be stunted, wasted, and underweight compared to their female counterparts. This finding is consistent with other findings from studies conducted in Ethiopia and several other countries in Sub-Saharan Africa (Christiaensen et al., 2004; Fenn et al., 2011; Medhin et al., 2010;Haile et al., 2016; Wamani et al., 2007; Sahn et al., 2002; Svedberg, 1990). In a meta-analysis of 16 Demographic and Health Surveys of 10 African countries, Wamani et al., (2007) assessed whether there exists a systematic sex differences in stunting prevalence in children less than five years of age in Sub-Saharan Africa. The pooled estimates for mean Z-scores were -1.59 for boys and -1.46 for girls with the difference being statistically significant. They also found that the sex differences in stunting were well defined in the lowest socioeconomic groups (Wamani et al., 2007). It remains unclear what accounts for the observed gender difference (Svedberg, 1990). However, researchers hypothesized the difference could be due partially to genetic factors, neglect, gender bias and difference in feeding practice (Medhin et al., 2010). The latter three are unlikely to be causes of the discrepancy in Ethiopia male children. Studies have shown that Ethiopian girls tend to receive less food than boys (Medhin et al., 2010).

Maternal education has been found in the literature to be an important determinant of child nutritional status and health (Chen et al, 2009). In line with other studies' findings, our study also revealed that maternal education has a positive impact on a child's nutritional status (Sahn et al., 1997; Christiaensen et al., 2004; Silva, 2005; Chen et al., 2009). Sahn and Alderman (1997), investigating determinates of child nutrition in Mozambique, found maternal education to be significantly associated with the nutritional status in children less than two-years of age. Researchers have suggested that more educated mothers have healthier children as a result of having more knowledge about nutrition and healthcare information; it might also be due to the reason that more educated mothers have healthier practices and are more likely to provide hygienic and safe living environments (Behrman et al. 1990; Strauss, 1990; Currie et al., 2003; Chen et al., 2009).

Maternal BMI less than 18.5 was used as a proxy for household food insecurity in this study. This study found that low BMI was significantly associated with wasting and underweight; however, it was not significantly associated with stunting. This finding is in agreement with that of the study conducted by Silva (2005) that also showed a significant association with underweight but not stunting. Since low BMI is an indicator of present nutritional status, which reflects the current food insecurity, it is understandable it affects the likelihood of a child becoming wasted and underweight rather than stunting, which is a long-term malnutrition (Silva, 2005).

The result of this study depicted that household wealth index, which is used as a proxy for household income, is a predictor of childhood malnutrition in Ethiopia. It is shown that children residing in households that are in middle or rich categories have better nutritional status compared to children living in household that fall under the poor category. This may be a result of poor households having limited source of food, which negatively impacts the nutritional status of children. Our result on wealth index is in accordance with a number of studies that have demonstrated an association between household wealth income and child nutritional status (Glewwe et al., 2002; Christiaensen et al., 2004; Silva, 2005; Kanjilal et al., 2010).

Place of residence in this study was significantly associated with child malnutrition. Rural residence was a predictor of stunting, wasting, and underweight status. This suggests that children in rural areas are the most susceptible groups in the country. Children in rural regions are at greater odds of being malnourished potentially because of poor living environments, recurrent food insecurity, low socioeconomic status, lack of access to healthcare systems and other public facilities (Medhin et al., 2010). The finding of this study is in agreement with a study conducted in Ethiopia that also showed a regional difference (Girma et al., 2002).

This study revealed that malnutrition in children aged below five years varied by different age cohorts. The probability of stunting and underweight increased with age up to 35 months and declined slightly from 35 months onwards. The odds of being stunted and underweight was the highest for children between the ages of 24-35 months compared to children younger than 6 months old (OR=12.6; OR=4.5, respectively). Although the odds of becoming stunted and underweight decreased after 35 months, both nutritional profiles showed higher odds up to 48-59 months compared to those less than 6 months. This finding is consistent with other study findings (Shrimpton et al., 2001; Kabubo-Mariara et al., 2009;Haile et al., 2016). On the other hand, the odds of a child becoming wasted was highest in children between the ages of 6-11 months. This is around the time when children are being introduced to complementary foods for the first time along with breast milk. The age at which this occurs has been associated with increased risk of diarrheal disease which results from contaminated weaning foods and a high risk of growth faltering (Cohen et al., 1994). This also affects child's height-for-age and weight-for-age. Furthermore, as children get older and start crawling their risk of coming into contact with contaminated water, food, and other environmental contaminants increases (Haile et al., 2016).

The result of this study also implies that stunting and wasting are independent of each other (Shrimpton et al., 2001). While status of wasted children improved after 11 months, that of stunted children continues past the 35 months. This is indicative of that fact that stunting begins at birth and continues past the first 3 years especially if proper interventions are not implemented in the first 1000 days (Shrimpton et al., 2001).

The findings of this study suggest that the likelihood of children becoming stunted, wasted, and underweight was lowest in children with average and large size at birth (based on the mother's assessment) compared to small size at birth. The association between birth size and malnutrition is supported by a study conducted in Malawi (Madise et al., 1997).

In the current study, diarrheal disease was associated with higher odds of wasting and underweight in children under five years of age. This finding is consistent with study conducted in different regions of Ethiopia (Asfaw et al., 2015; Yisak et. al., 2015). This could be in partly due to a reduction in appetite and nutritional absorption, which may result in weight lose among children experiencing diarrhea. Similarly, we also found a significant association between fever and both underweight and wasting. Compared to those who did not have fever two weeks prior to the survey, the odds of being underweight and wasted was higher among children who had fever. Our finding is in line with a study conducted using Kenya DHS that also found fever to be significantly associated with only wasting and underweight (Masibo, 2013).

In this study, about 36 percent of the households reported that they safely dispose the feces of their youngest child. The prevalence was slighter lower in our study compared to another study which was also conducted using 2011 EDHS; the researchers' finding showed that safe disposal in the country was about 34 percent (Azage et al. 2015). The discrepancy is likely from the difference in the categorization of disposal methods. Children living in households where child stool was unsafely disposed had higher odds of being malnourished of all forms compared to children in households where safe child feces disposal was practiced. Unsafe disposal of child feces in homes and open environments increases exposure to fecal pathogens, which can cause diarrheal disease and other infections that are associated with malnutrition (Azege et al. 2015; Majorin et al., 2014).

We observed a statistically significant association between time to get water and wasting. Children in which the household member traveled more than 30 minutes to collect water had higher odds of being wasted compared to children among households where travel time was 30 minutes or less. Studies have shown that time taken to collect water is associated with reduced volume of water available for household consumption and poor hygienic practice (Cairncross et al., 2006; Curtis et al., 1995). Contrary to our finding, a previous study conducted in Ethiopia found installment of taps in villages decreased the time to fetch water and child mortality, however, it showed an increase in child malnutrition (Gibson et al., 2006).

We now turn to the impact of household access to source of drinking water and sanitation facility on child's nutritional status. The data presented in this study showed that the majority of the households (N=2,320, 82.0%) do not have access to improved sanitation facilities. About 54% (N=4,774) of the households do not have access to improved source of drinking water.

The result of the bivariate analysis showed source of drinking water was a significant predictor of stunting, a reflection of chronic malnutrition. The significant association between source of drinking water and stunting remained after child's age, gender, and size at birth were accounted for in the multivariate analysis. However, after adjustments of maternal characteristic (maternal education) this association was attenuated. Additionally, the inclusion of household characteristics (place of residence, wealth index, and stool disposal) in our model further attenuated this association. Our finding is consistent with various studies that also found no significant association between source of drinking water and HAZ (Spears et al.; Esrey, 1996; Rah et al., 2015). Our results suggest childhood stunting that attributed household access to unimproved water is a function of childhood characteristics.

Our bivariate analysis also showed that stunting was significantly associated with access to sanitation facility (OR: 1.3; 95% CL 1.0-1.7 p-value 0.04). Adjustment of child's characteristics in our multivariate analysis increased this association (AOR 1.4; 95% CL 1.1-1.9). However, addition of maternal education reduced this association and lead to lose of significance. This may be due to the low level of educated mothers in Ethiopia. Finally, inclusion of household characteristic, although not significant, also revealed an association between sanitation facility and stunting (AOR: 1.1; 95% CL 0.8-1.5).

The result presented in our bivariate analysis showed that source of drinking water was not a predictor of wasting (OR: 1.0; 95% CL 0.8-1.3). Adjustment of childhood characteristics (age, gender, diarrheal disease, fever, and size at birth) also revealed no association. Our finding is consistent with Esrey's (1996) results, which also found no association between water and WHZ. An unexpected result was observed when we included maternal and household characteristics to our model. Our finding revealed reversed association between unimproved source of drinking water and wasting which suggests that having unimproved source of drinking water was protective against childhood wasting (AOR: 0.7; 95% CL 0.6-1.2). This may be a spurious association created by our modeling approach.

The hypothesized trend was observed with regards to the relationship between source of drinking water and underweight status in our bivariate analysis; however, it was not significantly associated (OR 1.2; 95% CL 1.0-1.4). Adjustment of childhood characteristics, did not significantly impact this relationship (AOR: 1.2; 95% CL1.0-1.4). However, the inclusion of maternal characteristic attenuated the relationship between source of drinking water and underweight status. Although not significant, the inclusion of household characteristics reversed this relationship (AOR 0.9; 95% CL 0.7-1.1). Similar to wasting results, this may also be a false association resulting from our modeling method.

Sanitation facility was significantly associated with childhood underweight status. This is in accordance with the study by Silva (2005), which also showed that sanitation and underweight were associated. The results of our bivariate analysis indicated that children in household with unimproved sanitation facility were 1.5 times more likely to be stunted compared to those in households with improved sanitation facility in our bivariate analysis. Adjustment of child characteristics increased the likelihood of being underweight (AOR: 1.6; 95% CL 1.2-2.2). Addition of maternal education slightly reduced this association (AOR 1.5; CL 1.1-2.0). Finally, inclusion of household yielded AOR 1.4; 95% CL 1.1-1.9.

5.2 Study limitations and strength

This study has several limitations. One of which is the cross-sectional nature of the dataset. This limits our ability to establish causal relationships. Another limitation of the dataset is that it employees some self-report questionnaires to collect data. Mothers, for example, are asked to report about child health factors like diarrhea, size at birth, and fever. Their accounts might be inaccurate because they might not recall the information or they choose to give false information. This can lead to misclassification and impact the validity of the study findings. Another limitation is that we utilized data from a retrospective records; this might also affect the validity of our findings and limited our ability to examine all variables that might have impacted our independent and dependent variables. Lastly, in our modeling approach, we might have controlled for intermediate variables that could have potential over- or under-estimated the measure of our association between our exposure and outcome variables.

The strength of this study is that the data used is a nationally representative dataset. The results of this study can be generalizable of the entire population.

5.3 Conclusion and recommendations

The high prevalence of malnutrition among children under-five years of age is a public health problem in Ethiopia. The nutritional status of children is a critical component of their health and future life achievements as adults. The cause of malnutrition is not just a result of nutritional intake, but also a result of multidimensional factors. As demonstrated in this study, access to sanitation facility and source of drinking water are factors that play a role in the nutritional status of children younger than five years. To tackle malnutrition in the country, governments programs and child nutritional initiatives should work to incorporate the WASH sector into their programs. As shown by our results, about 88 percent of the citizens of Ethiopia reside in rural regions of the country. The government investment to increase sanitation and water services, primarily sanitation services, in rural region can help lower the prevalence of malnutrition.

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