Addis Ababa University
Postgraduate Program

ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

PREVALENCE OF AND FACTORS ASSOCIATED WITH STUNTING AMONG UNDER-FIVE CHILDREN IN ETHIOPIA

FEKADE GETABIL

A Thesis Submitted to

The Department of Statistics

Presented in Partial Fulfillment of the Requirements for the

Degree of Master of Science in Statistics (Applied Statistics)

Addis Ababa University

Addis Ababa, Ethiopia

June 2012

Addis Ababa University

School of Graduate Studies

This is to certify that the thesis prepared by Fekade Getabil, entitled: *Prevalence of and Factors Associated with Stunting among Under-Five Children in Ethiopia* and submitted in partial fulfillment of the requirements for the Degree of Master of Science in Statistics (Applied Statistics) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Signed by the Examining Committee:

Examiner ______________________ Signature ______________Date __________

Examiner _____________________ Signature ______________Date __________

Advisor ______________________ Signature ______________Date __________

____

Chair of Department or Graduate Program Coordinator

Abstract

Prevalence of and Factors Associated with Stunting among Under-Five Children in Ethiopia

Fekade Getabil

Addis Ababa University, 2012

Stunting is a well-established child health indicator for chronic malnutrition related to environmental and socio-economic circumstances (WHO, 1995 and 1996). According to the 2011 EDHS report by the Ethiopia CSA, nationally, 44 percent of children under age five are stunted, and 21 percent of children are severely stunted. This study is an attempt to identify socio-economic, demographic and proximate predictors of stunting among under-five children in Ethiopia. In this study the data source is the Ethiopian Demographic and Health Survey conducted in 2011(EDHS 2011) by the Central Statistical Agency (CSA). The survey collected information on a total of 10,282 children aged less than 60 months out of which 8,487 children were considered in this study. In order to meet our objectives descriptive, multiple logistic regression and multilevel logistic regression statistical techniques were used for data analysis using socio-economic, demographic and health and environmental variables as explanatory variables and status of stunting as the response variable. The results of the analysis show that child's age, educational status of mother, educational status of partners, and low socioeconomic status were significant risk factors for stunting in under five children in Ethiopia. The results also suggested that children living in rural parts of the country and children from uneducated mothers are at higher risk of stunting.

ACKNOWLEDGEMENT

First and foremost, I would like to express my profound gratitude to my respectable advisor, Ato Mekonenn Tadesse, for his exemplary guidance, monitoring and constant encouragement throughout the course of this thesis work. His stimulating supports helped me in preparing my thesis within the time-frame.

I record with appreciation the help rendered by my dear classmates encouraging me to work hard. My best wishes to all who helped directly or indirectly in ensuring a better thesis write-up.

My deep appreciation and thanks goes to my friends Kassu Mehari and Mesfin Mulu for their help during the data analysis and providing me with invaluable comments and different supplementary material.

Finally, this might be a good opportunity to acknowledge all members of my family, relatives and friends for all their encouragement and support throughout my study.

Table of Contents

List of Tables

List of abbreviations

CSA	Central Statistical Agency
DHS	Demographic and Health Survey
EDHS	Ethiopian Demographic and Health Survey
FAO	Food and Agricultural Organization
LR	likelihood ratio
MDG	Millennium Development Goals
ML	Maximum Likelihood
NCHS	National Center for Health Statistics
SD	Standard Deviation
SE	Standard Error
UN	United Nations
UNICEF	United Nations Childrenǒs Fund
Var	Variance
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Research background

Stunting is a well-established child health indicator of chronic malnutrition related to environmental and socio-economic circumstances (WHO, 1995 and 1996). Childhood is a period of an active growth, covering the major transformations from birth to adulthood. Adequate nutrition is needed to ensure optimum growth and development of children. Normal growth is dependent on adequate nutrition, and human body can use carbohydrate, protein and fat as a source of energy. Inadequate intake of energy may lead to malnutrition in the long run (Mamoun et al, 2005). A stunted child is a child below his or her appropriate height for age (Rice et al, 2000). Stunting affects the physical and mental outcome of the children adversely.

Growth imposes a high metabolic demand throughout babyhood, particularly through the first year of life. High demands related to the increased rates of growth, higher amounts of active tissues per unit of body mass (e.g. brain), and happening of disease are among the factors making babies a vulnerable group (Mamoun et al, 2005).

Other factors pertinent to making babies a vulnerable group are limitations of supply. This limitation is related to the immaturity of systems whether an absorptive, metabolic, or excretory system. Children are susceptible to neurological impairment, psychological disorder, and growth retardation, because of the fact that they are in the developmental stage. On the other hand; the absence of parents, thorough knowledge about complementary feeding, educational deficiencies, and socio-economic deprivation, impel babies to be a vulnerable group. Other factors represented by the disequilibrium in body composition; are depletion of nutrient stores which is lost in the absolute body size, and tissue composition (Rolfes et al, 2004).

Growth is not merely an increase in body size. As baby grows up his/her body properties alter reflecting maturation in body composition and changes in the partitioning of nutrients between organ systems in a programmed way. Severe energy demand or restriction leads to a situation which may not be recoverable, while the growth is rapid and the brain is still developing. The end result is stunting with associated impairment of childôs cognitive ability (Rolfes et al, 2004).

Optimizing nutrition in early life is increasingly seen to have effect on long term health. Patterns of growth in babyhood are correlated with the later risk of metabolic disease. The challenge of optimal babyhood nutrition is to match supply with demand throughout this period of life (Rolfes et al, 2004).

Malnutrition could be a consequence of unfavorable condition and is associated with poor development and disturbances in mental and intellectual capacity (Scrimshaw, 1998).

A recent analysis by Maternal and Child Malnutrition Study Group (MCMSG) in 2005 based on data from several countries has provided new estimates of the global prevalence of stunting among children below 5 years of age, based on the new WHO Child Growth Standards. Of the 556 million children under 5 years in low-income countries; 32% (178 million) were stunted. Stunting contributes to child mortality and disease burden. Of the almost 10 million deaths annually among children below 5 years of age, it was estimated that the attributable fraction of stunting was15% (Michaelsen et al, 2008).

Every five seconds a child dies because she or he is hungry. Under-nutrition in children under the age of 18 affects an estimated 350 to 400 million children. More than 70 percent of the worldôs 146 million underweight children under age five live in just 10 countries and 10.9 million children under-five die in developing countries each year. Malnutrition and hunger-related diseases cause 60 percent of the deaths. One out of four children - roughly 146 million - in developing countries is underweight. (UN: website, 2007).

Growth stunting is a population-based indicator. It indicates the prevalence of nutrition related disorders among children and is defined as height for age below the fifth percentile on reference growth curves. Stunting starts in the beginning of life and persists away. When it begins, it is considered as a major risk factor for increased mortality in the future (Lewit and Kerrebrock, 1997).

The assessment of childôs nutritional status is accomplished by clinical and physical examination, anthropometric measurements (including Height, Weight, and Mid Upper ArmCircumference.etc), biochemical analysis (including hemoglobin level, presence of microbes and worms, certain minerals and vitamins), and taking previous history especially dietary history from the caregivers. The researcher should take into consideration that he takes a thorough dietary history from the caregivers, because the nutritional status at the time of consultation reflects what has happened since conception (Rolfes et al, 2004).

According to the Ethiopia CSA report in 2011 EDHS nationally, 44 percent of children under age five are stunted, and 21 percent of children are severely stunted. In general, the prevalence of stunting increases as the age of a child increases, with the highest prevalence of chronic malnutrition found in children age 24-35 months (57 percent) and lowest in children under age six months (10 percent). Male children are slightly more likely to be stunted than female children (46 percent and 43 percent, respectively). With the exception of first order births, there is an inverse relationship between the length of the preceding birth interval and the proportion of children who are stunted. The longer the interval, the less likely it is that the child will be stunted. In this study, we will be focusing on stunting as an indicator of malnutrition.

1.2 Statement of the problem

The nutritional and health status of children in Ethiopia are among the worst in the world. For example, almost one in every 17 babies born in Ethiopia (59 per 1000) does not survive to celebrate its first birthday, and one in every eleven children (88/1000) dies before its fifth birthday. As a result, it will be challenging to reach the child survival Millennium Development Goals (reducing child mortality by 3/4) with the current pace of mortality reduction (WB, 2011).

High malnutrition rates in Ethiopia pose a significant obstacle to achieving better child health outcomes. Malnutrition among under-five children is a chronic problem in developing countries like Ethiopia. Worldwide, ten and a half million children of age under-five die every year, with 98% of these deaths reported to occur in developing countries (UNICEF, 2007). In recognition of the burden of malnutrition among under-five children, four of the eight United Nations Millennium Development Goals (MDGs) are specifically directed towards improving child health outcomes in developing countries. In particular, a reduction in the mortality of children is a key MDG, and a reduction in malnourishment among children is an important indicator of progress towards that goal.

Based on the 2011 Ethiopian Demographic and Health and Survey (EDHS), children under age five, the prevalence of stunted (their z-score less than -2) at country level is reported 44 percent. The figures given show the extent to which how much of the country҆s potential work force is faced with growth retardation.

Even though the problem of child malnutrition in Ethiopia has been sufficiently documented, the reasons behind it are still poorly understood. There is also inconsistency across studies regarding the determinant factors behind childhood stunting. Therefore, this study attempts to investigate the major socio-economic, demographic, health and environmental determinants of stunting in Ethiopia.

1.3 Objective of the study

The **general objective** of this study is to determine the prevalence of stunting and identify risk factors associated with stunting among under-five children in Ethiopia.

The **specific objectives** of this study are:

1. To identify the most important socio-economic, demographic, and environmental factors associated with stunting among under-five children in Ethiopia.
2. To estimate the level of predictors for stunting among under-five children in Ethiopia.
3. To make relevant recommendations for policy makers, program managers as well as development planners.

1.4 Significance of the study

The study was conducted to investigate the main risk factors related to stunting. Through this research an analysis of children nutritional status in relation to demographic, socio-economic, and feeding practice is presented.

It is hoped that the finding of this study will identify the risk factors for stunting among children aged less than five years in Ethiopia.

In addition to this, the findings could be helpful for policy making, monitoring and evaluation activities of the government and different concerned agencies. Since the study will attempt to reveal the major factors for childhood stunting, it will help to guide the end user governmental and non-governmental organizations to develop nutrition programs and set appropriate plans to tackle the existing health and nutrition problems. Finally, the study could be used as a stepping stone for further studies.

1.5 Limitation of the study

The data used here being secondary may have a number of limitations on the outcome of this study.

- Though there are many factors associated with stunting as indicated by different studies in different countries, this study is undertaken to explore a few of the socio-economic, demographic, health and environmental factors in Ethiopia.
- The study did not make a comparative analysis of stunting between rural and urban households in the country.
- Absence of periodical reports, and approved resources.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Framework and Definitional Considerations of Stunting

Conceptual framework is defined generally as a structure for supporting or enclosing something else, also it is a set of assumptions, concepts, values, and practices that constitute a way of viewing reality (Collins English Dictionary, 2003).

UNICEF defined the nutrition conceptual frame work as a set of assumptions designed to facilitate the process of assessing, analyzing and deciding on what actions to take at all levels of society to resolve nutrition problems. This is also known as the ñTriple Aò process (Assessment, Analysis, Action) (Shrimpton and Kachondham, 2003).

Previous studies show that success in conceptualizing and implementing programs to reduce stunting by combining disease control strategies with the promotion of breastfeeding and optimal complementary feeding has been demonstrable. Repositioning nutrition is cardinal to develop. Childcare practices, which include feeding practices, appear in the conceptual framework of malnutrition (Shrimpton et al, 2003). As shown in this study, the overall three groups of risk factors of stunting in children less than five years are:

- Immediate risk factors; including child characteristics, adequate dietary intake, and infectious diseases.
- Underlying risk factors; including food security which means availability of food, unhealthy environment, and health knowledge.

- Basic risk factors including; economic factors, household factors, and community factors, and caregiver characteristics.

A seven-dimension framework to identify stunting-related factors that might have influence on a child's nutritional status was constructed as in Abdeljawad (2008). Each dimension comprises several variables selected to build up a comprehensive scenario, and this model highlighted the importance of identifying a number of conceptually grounded dimensions that could be associated with stunting (Abdeljawad et al, 2008).

- Demographical variables and the effect of household portion on the time spend by mother to care for the child.
- Family and family related factors (parent's literacy percentage of income spent on food, family structure, cordoning of the family, number of members of the family, and the presence of both parents).
- Care given to the child (as economic, and health care).
- Family income: parents' employment (job, time on the same job, per capita family income), unemployment.
- Patterns of breast feeding, weaning practices, and other dietary practices.
- Child health status (having infectious disease, number of visits to the clinics). In addition, child characteristics (age, sex, and birth order and birth weight) are also included.
- Mother͡s status (educational level, height, mothers discipline and not negligence).

The dimension of family structure, which included demographic characteristics of the parents, and literacy attainment, are associated with the nutritional status of children. In urban areas, it is noticeable that the economic load on poor families with numerous children led the mother to give less attention to her babies, whose nutritional status suffered in consequence. This result asserts the importance of considering birth control when developing health programs (Noman, 2004).

Regarding the dimension family and family related factors and care given to the baby in this study, the presence of extended big families has been related to the presence of stunting, while exclusive supply of care by the mother to her baby showed a protective effect. These findings emphasize the role of the mother as primary caregiver for her family members especially the younger; thus when a mother is present to care for the baby, the effects of living in a poor environment canῷt get better.

2.1.1 Malnutrition

Malnutrition is an important universal health problem, and the single biggest contributor to child mortality in Eastern Mediterranean Region. A key indicator of chronic malnutrition is stunting when children are too short for their age group compared to the WHO child growth standards. About 178 million children globally are stunted, resulting from not enough food, a vitamin and mineral-poor diet, and disease (WHO, fact files: website, 2007).

In developing countries, stunted growth is a common problem affecting a large percentage of children, and it is one of the main health problems in Ethiopia. Malnutrition of young children occurs mainly under conditions of extreme poverty and deprivation; it has a huge impact on their linear growth, activity, and level of their cleverness and intelligence. Stunting is also closely linked to impairments in mental development, and it is associated with high morbidity and mortality rates among children (Rolfes et al, 2004).

Stunting is a primary manifestation of malnutrition in early childhood, including malnutrition during fetal development brought on by the malnourished mother. Sometimes not only known as chronic malnutrition but also it is considered a serious type of malnutrition because its development occurs slowly throughout time before its appearance.

2.1.2 Definition of stunting

Stunting as an expression was introduced in the 1970s by J.C.Waterlow describing the linear growth retardation in children that results in decreasing their height with referring to age caused by prolonged nutritional destitution (Kikafunda et al, 1998).

Stunted growth is a reduced growth rate in human development. Once established, stunting and its effects typically become permanent. Stunted children may never regain the height lost as a result of stunting, and most children will never gain the corresponding body weight. It also leads to premature death later in life (Olivieri et al, 2008). Stunting, or chronic malnutrition, defined on the basis of the height to age ratio, shows malnutrition resulting from cumulative inadequacies in the childõs nutritional status (Shaikh et al, 2003).

Growth failure is a deficiency in weight and height for age; it tends to appear from about four months of age amongst poor children. The majority of weight deficiency is strongly associated with height deficiency. In other words; stunting frequently occurs without wasting, but only mild wasting cases occurs without stunting (Rolfes et al, 2004).

According to World Health Organization recommendations, the cuts off put to define stunting were less than two z-scores of height for age. Stunting has been considered as an indication of chronic malnutrition or something that has happened in the past, but this is a misconception since although the nutritional insult may have happened in the past the consequent process is still ongoing. Stunted children are more likely to get sick and die than underweight or wasted children are (Shrimpton et al, 2003).

Stunting as a well being health indicator is used to describe the level of child malnutrition. Stunting or low height-for-age measures linear growth retardation and cumulative growth deficit. It also indicates the effect of past nutritional insult in the life of the child (Genebo and Girma, 2002). The proportion of children who are more than 2 standard deviation units (z-score) below the median of the international reference population are considered moderately stunted and those who fall more than 3 SD units below are severely stunted (Padmadas, Hutter and Willekens, 2002).

Stunting is a cumulative process of poor growth that primarily occurs before the age of 3 years and is not easily reversed, whereas child growth is considered a good indicator of overall socioeconomic development and human welfare in developing countries. Growth retardation is a physical indicator of a broad spectrum of nutritional deficiencies and is often linked to poor mental development (Lang, 1998).

Growth stunting is defined by comparing measurements of childrenös heights to the NCHS growth reference population; children who fall below the fifth percentile of the reference population in height-for-age are defined as stunted, regardless of the reason of their shortness (Lewit and Kerrebrock, 1997).

Stunting is a good indicator for the general health and prosperity, as it reflects the constructive medium surrounding malnutrition. It is difficult for a stunted child at definite phase in childös growth cycle to regain their missed growth and almost impossible for them to recuperate completely, as this would need veritable progress in the quality of Childôs life (Rolfes et al, 2004).

Moderate and severe stunting cases increase with age up to 1-2 years. From the second year of age forwards, it remains at stable levels. This is attributable to the fact that during the first year of life the childôs nutritional demands can still be met with breast milk. As age increased, poor quality complementary foods, nourishment practices and frequent exposure to ailment, lead immediately to growthôs impairment.

2.2 Prevalence of stunting

Data on the prevalence of protein energy malnutrition in developing countries (low- and middle-income countries) indicate that on average, stunting affects over 40% of fewer than 5 years children, and stunting rates among children are highest in Africa and Asia. Thin and short were used in the past to refer to children with abnormal health and nutritional status. Nowadays; wasting and stunting are believed to insinuate deviation behind the range of thinness and shortness that might be regarded as normal in some cases. It soon became apparent that stunting is generally more common than wasting, and in some populations, particularly in Asia, over 50 % of children could be classified as stunted (Onis et al, 1993).

In a study drawn on the experience of 63 developing countries over the 25-years period to identify the determinants of child malnutrition for each developing region, only seven countries have a higher prevalence of child stunting than Bangladesh. While Bangladesh has the highest prevalence of childhood underweight among all countries in the world, except North Korea, the percentage of children aged less than 5 years with stunting decreased from 64.2% in 1992 to 48.3% in 2000 and 42.4% in 2005 (Rahman, Mostofa and Nasrin, 2009).

In developing countries, stunting affects about a third of the children below five years of age. The highest levels of stunting are observed in eastern Africa, where on average 48.1 % of under-five children are stunted. In 1998 a demographic health survey (DHS) done in Kenya showed that the prevalence of stunting was 22%. Another DHS done in 2003 showed little improvements with the prevalence of stunting dropped to 20%. On the other hand in the central province, lower improvements were observed with the prevalence of stunting reduced to 28%. By the year 2007 some11% of males and 16% of females were found to be stunted in Kenya (Veronicah, Kogi-Makau, and Muroki, 2007).

Although, the worldwide prevalence of stunting is declining by about 0.5 percentage point each year, more than half the children in some regions of the developing world, such as Southeast Asia, are severely below the normal height for their age (according to Cornell university nutritionist, 1998). In 1995, of under five children 54 % in South Asia, 39 % in sub-Saharan Africa, 38 % in Southeast Asia, 28 % in Mexico, Central America and the Caribbean, 22 % in the Near East and North Africa, and 13 % in South America where stunted. In 1992, 31 % of under five children in China were stunted (Lang, 1998).

Globally, stunted growth has declined from 49 % of children under 5 years of age in 1980 to 40 % in 1995. All the regions in the developing world except sub-Saharan Africa made some progress in reducing stunted growth among children under 5 between 1980 and 1995. However, stunted growth in sub-Saharan Africa had gone up by 0.13 percent a year. Of the 25 countries in the sub-Saharan region with data available, however, 13 made substantial progress, but in 12 countries, the rate of stunting got worse (Lang, 1998).

By the year 2000, the prevalence of the stunting was higher than underweight or wasting in developing countries. As a whole, 41 % of under-five children were stunted, and one third experienced retarded growth in East and South East Asia. More than 80% (total 215 million) of stunted children in developing countries lived in low income countries of Asia, such as Bangladesh, India, Pakistan, Lao People Democratic Republic, Vietnam, Myanmar, and the Philippines (Nandi, 1999).

2.3 Nutritional assessment of stunting

Globally, height-for-age has been used as the indication of growth assessment according to WHO and NCHS standards. These international standards test the accuracy of anthropometric measures from around the world. Anthropometric measurements are converted into three indexes: H//A, W//A, and W//H which have been expressed as Z score relative to the international (NCHS, WHO, and CDC) reference population to standardize the distribution. A childôs nutritional status is then categorized by his or her height-for-age or weight for height Z scores. A child is categorized as stunted if his or her height is less than that of the child of the same age with a value 2 standard deviations below the reference median height for age (Ricci and Becker, 1996)

For children less than 2 years of age, recumbent length was used in the anthropometric calculations, and for children of age 2 years and higher, standing heights were used. Low anthropometry was defined as a Z-score < 2 SD. (Hassan et al, 1997). The stunting is considered mild if Òthe mean (- 1SD), moderate if Òthe mean (- 2SD), and severe if Òthe mean (- 3SD).

2.4 Risk factors associated with stunting

Some evidences indicated that the economic status of a household, use of health services, availability of improved water sources, availability of sanitation facilities, education status of both mother and father, place of residence (whether from rural or urban areas), fatherôs employment and control over income, motherôs age, child nutritional status, age of child, birth order show a progressive increase in malnutrition rates, risk of stunting, as well as increased risk of illness in developing countries (Genebo and Girma, 2002).

A multilevel logistic regression study published in March 2009 concerned with individual and contextual factors associated with childhood stunting in Nigeria revealed that low income, low maternal educational level, short maternal stature, and mother's over evaluation of her childôs height are independent risk factors for a child to be stunted overweight. (Uthman, 2009).

Stunting is often associated with long term dietary inadequacy, repeated infection or both (Caulfield et al, 2008). Stunting caused by a chronic case of under nutrition which delays growth and causes irreversible damage containing shorter height, low birth weight, low income and decreasing scholarly accomplishment. Under-nutrition and micro nutrient deficiencies contribute substantially to the global burden (Victora et al, 2008).

Stunting is an outcome of various factors resulting from unfavorable socioeconomic condition including irregular income and limited educational achievement. These conditions deteriorate by an equal distribution of nutrition among family members. In some families, parents are able to maintain the adequate nutritional status of their children whereas in other families parents cannot. Maternal and parental education also plays a role; no or lower level of education is associated with increased incidence of stunting. A study by Semba et al, (2008), showed that

3-5 % of reduced risk of stunting with each year of extra parental education. In this regard, education reflects income, knowledge, empowerment and ability to act on new information.

Taking into consideration the relationship between childôs nutritional status especially weaning practices and stunting; Padmadas et al, (2002) in a study have found that, the introduction of complementary feeding below 6 months of age significantly reduces stunting among children aged two and four years of age in India. It was found that the inclusion of demographic, health, social and region variables mediated the effects of weaning on stunting. The study suggests that breastfeeding alone to 6 months may not be a good option for the optimal growth of children, whereas stunting appears to be comparatively lower for children weaned at completed age 3 months. They concluded that overall prevalence of stunting is extremely high in India.

A descriptive study done in urban Uganda areas to evaluate the causes of early childhood malnutrition revealed that stunting was highly prevalent with 41.6% of the children stunted. A logistic regression analysis identified a range of factors including dietary (prolonged breastfeeding from >18 months to <24 months), low energy density of complimentary foods, factors related to the caretaker (education level of the mother and low socio-economic status), and environmental factors as important factors playing major roles in the nutritional status of children in developing countries (Turyashemererwa et al, 2009).

In 2009, a multivariate multinomial logistic regression study done in rural Bangladesh, reveals that motherôs education level, poor socioeconomic conditions, fatherôs education and occupation emerged as important factors. Intake of vitamin A also has positive effect on better nutritional status of children aged 12-59 months (Rahman et al, 2009).

Vitolo et al (2008) used descriptive statistics to determine the prevalence of stunting and multivariable logistic regression model to identify some of the risk factors associated with overweight, stunting and wasting among children under-five years of age. The data revealed that 9.1% of the 3957 children studied were stunted. Conversely, the multivariable logistic regression model suggested that stunting was associated with low economic status and poor sanitation of the area (OR = 2.36), three or more siblings (OR = 3.12), low birth weight <2500g (OR==3.49) ,child age < 36 month (OR = 1.77) and mothers age <20 years (OR = 1.60).

In 2008, a multivariate multilevel logistic regression study by Hien and Kam (2008) dealing with nutritional status and the characteristics related to malnutrition in children less than five years of age in Vietnam indicated that region of residence, the mother's level of education and occupation, household size, number of children in the family, weight at birth and duration of exclusive breastfeeding are significant stunting risk factors.

A matched case control study by Solomon and Zemene (2008) on the risk factors for severe acute malnutrition in children under the age of five revealed that the socio economic risk factors for severe acute malnutrition were the maternal illiteracy (OR = 3.83), paternal illiteracy (OR = 2.04), low family income (OR = 3.44) and large family size with the number of children greater than 3(OR = 1.96).

Further analysis with logistic regression revealed that, the risk for severe stunting was independently associated with lack of exclusive breastfeeding for the first six months of life (OR = 3.22) and late initiation of complementary diet (OR = 3.39) (Solomon and Zemene, 2008).

The major findings of study by Mamabolo et al (2005) on the prevalence and determinants of stunting in 3-year-old black South African children indicated that about half of the children under study were stunted. The result of the binary logistic regression analysis revealed that living in a household with nine or more individuals increased the risk of being stunted eight-fold while having a mother who was a student increased this almost four-fold. Having a student mother, considered as a major risk factor, which may be explained by the resulting reduced family income and individual care and attention given to the child, as the mother has left her child with another caretaker during the day.

Freedman et al, (2004) used a multivariate model to assess the relationship between demographic and clinical variables and height-for-age Z-score, an indicator of achieved linear growth reflecting the long-term cumulative effects of health and nutritional intake. The results illustrated that amongst risk factors related directly to stunting are age, severe anemia (hemoglobin < 7 mg/dl), history of diarrhea in the past 2 weeks, recent treatment of malaria conventional medication), high-density parasites in blood (parasitemia), combined level of education for the head of household (primary caretaker), and socioeconomic status.

Some evidence in developing countries indicated that malnourished individuals that is, women with a body mass index (BMI) below 18.5, poor economic status of a household which is an indicator of food supplies, use of health services, availability of improved water sources, and sanitation facilities, education status of both mother and father, place of residence (whether from rural or urban areas), fatherôs employment and control over income, motherôs age, child nutritional status, age of child, birth order show a progressive increase in malnutrition rates, risk of stunting, as well as increased risk of illness (Genebo and Girma, 2002).

From the theoretical and empirical causes and determinants of stunting, it can be generalized that stunting is a function of socio-economic, demographic, health and environmental factors.

CHAPTER THREE

DATA AND METHODOLOGY

3.1 Data source

The source of data for this study is the 2011 Ethiopia Demographic and Health Survey (EDHS) which is obtained from Central Statistical Agency (CSA). It is the third major survey designed to provide estimates for the health and demographic variables of interest for the following domains: Ethiopia as a whole, urban and rural areas of Ethiopia (each as a separate domain), and all geographic areas (nine regions namely: Tigray, Affar, Amhara, Oromiya, Somali, Benishangul-Gumuz, Southern Nations, Nationalities and Peoples (SNNP), Gambela and Harari regional states and two city administrations, Addis Ababa and Dire Dawa). In the 2011 EDHS a representative sample of approximately 17,018 households from 624 clusters was selected. The sample was selected in two stages. In the first stage, 624 clusters (187 urban and 437 rural) were selected from the list of Enumeration Areas (EA).

From 10,282 under-five children only 8,487 are measured for anthropometric measurements height and weight. Thus, the analysis presented in this study on the status of stunting is based on the 8,487 under-five children with complete anthropometric measurements.

3.2 Variables of the Study

As demonstrated in the literature review, socio-economic, demographic, health and environmental characteristics are considered as the most important determinants of stunting in under-five children.

3.2.1 The Response variable

In different studies the response variable height-for-age (stunting) measurement status was expressed in Standard Deviation (SD) units (Z-score) from the median of the reference population. Children with a measurement of <-2 SD units from the median of the reference population were considered short for their age (stunted) and children with measurement of (Ó-2SD) units from the median of the reference population were not stunted.

In this study, the measurement height-for-age was calculated using the new Child Growth Standards released by the World Health Organization in April 2006. The new Standards are the result of an intensive study initiated by WHO in 1997 to develop a new international standard for assessing the physical growth nutritional status and motor development in all children from birth to age five. WHO and its principal partner, the United Nations University, undertook a Multi-centre Growth Reference Study which is a community-based multicounty project involving more than eight thousand children from Brazil, Ghana, India, Norway, Oman, and the United States of America. The measures are presented with two implied decimal places.

To determine the level of stunting, the dependent variable was expressed as a dichotomous variable category 0 if not stunted (Ó-2SD) and category 1 if stunted (<-2SD). In view of this, the response variable, the status of stunting of the i^{th} child was measured as a dichotomous variable:

ı ı ı ı 0,ı ı ı ıı ı ı ı ı ı ı ı 2ı ı ıı 2 ı ı ıı ı ı ı ı ı ı ı ı ıı ı ı ı ı ıı ı ı ı ı ı ı ı ı ı ı ı ı ı
1,ı ı ı ı ı ı ı ı ı 2ı ı ıı 2 ı ı ı ı ı ı ı ı ı ı ı ıı ı ı ı ı ıı ı ı ı ı ı ı ı ı ı ı ı

where Y_i is the status of stunting of i^{th} child

3.2.2 Explanatory variables

The predictor variables to be studied as determinants of childhood stunting are grouped into socio-economic, demographic, and health and environmental factors.

i. Socio-Economic Characteristics

Among the socioeconomic characteristics that may increase or decrease the risk of stunting of under-five children, the following factors are included: motherꞌs education, employment status of the mother, employment status of partner, education of husband/partner, household income, household size, place of residence and geographical region.

ii. Demographic Characteristics

Demographic characteristics included are age of the child, sex of the child, birth interval and birth order of the child.

iii. Health and Environmental Characteristics

There are certain health and environmental characteristics that may increase or decrease the risk of stunting among children. Diarrhea, fever, water supplies and toilet facilities are important health and environmental factors included in this study.

Table 3.1 Description of the Variables and coding

The Response Variable

Variable	Representation of variable	Factor categories
Stunting	Y	0, not stunted 1, stunted

Explanatory Variables/factors

1. Demographic variables

Variables	Categories
Sex of child(SECH)	0 = Female 1 = Male
Birth interval of the child in Month(BIRINCH)	0-24months 25-47 months 48-59 months
Age of child(AGECH)	0= <6 months 1= 6-11 months 2= 12-23 months 3= 24-35 months 4= 36-47 months 5= 48-59 months
Birth order of the child(BIROCH)	0 = 1 1 = 2-3 2 = 4-5 3 = 6+

2. Socio-Economic Variables

Variables	Categories
Motherôs Education(EDUM)	0= No education 1= Primary education, 2= Secondary and above
Employment status of mother (EMPM)	0=Unemployed 1= Employed
Wealth index(WLND)	0= Poor 1= Medium 2= Rich
Education of husband/partner (EDUP)	0= No education 1= Primary education 2= Secondary and above
Number of household member	0=1-4

(NHHM)	1=5-9 2= 10 and above
Place of Residence (PRISID)	0= Rural 1= Urban
Region (REGION)	0= Tigray 1= Afar 2= Amhara 3= Oromia 4= Somali 5= Ben-gumuz 6= SNNP 7= Gambela 8= Harari 9= Addis Ababa 10= Dire Dawa

3. Health and Environmental Characteristics

Variables	Categories
Source of drinking water (SORDW)	0= Non improved source(surface water, tanker truck, unprotected well/spring, otherôs) 1= improved source(piped into dwelling, piped to yard/plot, public tap, protected well/spring, rain water, bottled water)
Had Diarrhea in the two Weeks before survey (DIARRHEA)	0=No 1= Yes
Had fever in the two weeks before survey (FEVER)	0= No 1= Yes
Type of toilet facility (TOILET)	0= No facilities (bush/field toilet, hanging toilet, others) 1= Have facilities (Pit toilet, Flush/pour toilet)

3.3 The Methodology

A range of techniques have been developed for analyzing data with categorical dependent variables, including discriminant analysis, probit analysis, log-linear regression and logistic regression.

Logistic Regression and Linear Discriminant Analysis are the widely used multivariate statistical methods for analysis of data with categorical outcome variables. Both of them are appropriate for the development of linear classification models, i.e. models associated with linear boundaries between the groups (Tabachnich and Fidell, 2007).

Nevertheless, the two methods differ in their idea. In instances where the independent variables are categorical or a mix of continuous and categorical, logistic analysis is preferred to discriminant analysis (Agresti, 1996). The assumptions required for statistical tests in logistic regression are far less restrictive than those for ordinary least squares regression. There is no formal requirement for multivariate normality, homoscedasticity, or linearity of the independent variables within each category of the response variable. However, the assumptions that apply to logistic regression model include: meaningful coding, inclusion of all relevant and exclusion of all irrelevant variables in the regression model, low error in the explanatory variables, no outliers and sampling adequacy (the representativeness of sample size).

While Logistic Regression makes no assumption on the distribution of the explanatory data, Linear Discriminant Analysis has been developed for normally distributed explanatory variables. It is therefore reasonable to expect Linear Discriminant Analysis to give better results when the normality assumptions are fulfilled, but in all other assumptions Logistic Regression should be more appropriate (Maja *et al.*, 2004).

The response variable in this study is a dichotomy variable hence, this study uses logistic regression to meet the objectives set. The study also uses multilevel logistic regression analysis to analyze factors associated with childhood stunting because of the hierarchical nature of the data set. Three multilevel models were constructed for the analysis. The first model, an empty model, was without any explanatory variable i.e. simple component of variance analysis. The second model controlled for the individual-level variables, the third model controlled for community-level variables.

3.3.1 The Logistic Regression Analysis

Logistic regression is a popular modeling approach when the dependent variable is dichotomous or polytomous. This model allows one to predict outcomes from a set of variables that may be continuous, discrete, dichotomous, or a mix of any of these. Hosmer and Lemeshow (2000) have described logistic regression focusing on its theoretical and applied aspect. Logistic model, as compared to its competitor, the probit model, is less sensitive to outliers and easy to correct a bias (Copas, 1988).

In the terminology of logistic regression analysis the odds of a success is defined to be the ratio of the probability of a success to the probability of a failure. Hence if p is the true success probability, the odd of a success is $\frac{1}{1\ 1\ 1}$.

Regression methods are integral components of any data analysis concerned with describing the relationship between a response variable and one or more explanatory variables. When the outcome variable is binary, the logistic regression model can be used mainly for two reasons. The first is from a mathematical point of view; it is extremely flexible and easily used function. The second is, it lends itself to meaningful interpretation.

3.3.2 The Multiple Logistic Regression Analysis

Multiple logistic regression analysis is used to study the effects of each independent variable controlling other factors on the response variable, which is status of stunting in under-five children. An important aspect in multiple levels of analysis is the partitioning of unexplained variability over the various levels. The logistic regression can have an arbitrary number of parameters and terms in the model representing qualitative variables, quantitative variables and interaction terms in order to model a dichotomous or categorical outcome variable. When explanatory variables are included to model probabilities, a problem is that probabilities are restricted to the domain 0 and 1whereas a linear effect for an explanatory variable could take the fitted value outside this interval.

Let Y be a dichotomous outcome random covariate with categories 1 (stunted) and 0 (not stunted). Consider a collection of *k* independent variables which will be denoted by the vector

X = ($x_{1,}$ $x_{2,\dots}$,x_k). Let the conditional probability that the outcome is present be denoted by *P(Y=1| X) = P(X).*

Then the logit of the multiple logistic regressions is given by the equation

11 1 11 1 $\frac{1}{1 1 1}$ 1 1 11 1 11 $^{1 11 1}$ 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3.1

Where, 1 11 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

In which case,

1 11 1 1 $\frac{1^{1 11 1}}{1 1 1^{1 11 1}}$ 1 $\frac{1^{1 1 1 1 1 1 1 1 1 1 1 1 1 1}}{1 1 1^{1 1 1 1 1 1 1 1 1 1 1 1 1 1}}$. 3.2

In order to estimate the parameters, maximum likelihood-based iteration algorithms can be employed. In spite of the attractive properties of the logit function, it is by no means the only suitable function for transforming probabilities to arbitrary real values.

Variable Selection: The number of variables to be included in the model should be of the minimum possible that is parsimonious and deliver optimum information. In this study the variable selection process begins with a univariate analysis of each variable. Tests to determine whether a systematic relation or association between each predictor variable with the response variable exists are made before the final model was selected. A univariate logistic regression and a likelihood ratio (LR) chi-square test (for a 2 L contingency table) will be employed to examine the importance of each predictor variables to the outcome variable.

Upon completion of the univariate analysis, predictor variables for the multivariate analysis were selected with a condition that any variable whose univariate test has a p-value less than 0.25 was considered as a candidate for the multivariate model along with all variables of known socio-demographic or economic importance (Hosmer-Lemeshow, 1989).

In order to determine the number of predictor variables to be considered in a study, some literature suggest that there should be 50 cases for each predictor while others recommend 10 cases per predictor. In general, there should be significantly fewer independent variables than the ordinary least squares regression. In this regard, a rule of thumb is that there should be no more than one independent for each 10 cases in the sample. In applying this rule of thumb, if there are categorical independent predictors such as dichotomous, the number of cases should be considered to be the lesser of the groups.

For multivariable model, a stepwise method in which variables are selected either for inclusion or exclusion from the model in a sequential fashion based solely on statistical criteria was used. There are two main versions of the stepwise procedure: (a) forward selection with a test for backward elimination, and (b) backward elimination followed by a test for forward selection. The study will employ stepwise forward likelihood ratio procedure in order to select the list of predictor variables that will have joint impact in influencing the outcome variable.

The final decision on the inclusion of each predictor variable will be made on the examination of the Wald statistic for the variable, and comparing each estimated coefficient of the particular variable on the multivariable regression model with the univariate estimate of the model containing only that predictor. Variables that do not contribute to the model based on these criteria will be eliminated and a new model will be fit. The new model will be compared with the old model through the LR test. Also, the estimated coefficients for the remaining variables were compared to those from the full model. In view of this (deletion, refitting and/or verifying) was performed. Having obtained a model that contains the essential variables, the need to include interaction terms in the model will be assessed by creating the appropriate product of the variables in question. Assessment of the significance of each interaction term will be made using a LR test. Interactions that do not contribute to the improvement of the model will be discarded and the model with main-effects will be maintained.

3.3.2.1 Parameter Estimation

The maximum likelihood and non-iterative weighted least squares are the two most competing estimation methods used in fitting logistic regression model (Hosmer- Lemeshow, 1989; Greene, 1991, Collet, 1991 and others). When the assumption of normality of the predictors does not hold, the non-iterative weighted least squares method is less efficient (Maddala, 1997). In contrast, the maximum likelihood estimation method is appropriate for estimating the logistic (logit) model parameters due to the less restrictive nature of the underlying assumptions (Hosmer-Lemeshow, 1989). Hence, in this study the maximum likelihood estimation technique will be applied to estimate parameters of the model.

Consider the logistic model, ı ı ı ı ı ı ı ı / ı ı ı ı ı ı ı ı 3.3

Where, ı ı ı ı ı ı ı, ı ı ı, ..., ı ı ı ı ı

$\boldsymbol{\beta}$ = (ɓ$_0$, ɓ$_1$, ɓ$_2$é ɓ$_k$)' are the model parameter

Since observed values of **Y** say, y_i's (i= 1, 2... n) are independently distributed as Bernoulli with parameter p_i, y_i~ Bernoulli (1, p_i), the likelihood function of ***Y*** is given by:

ℓı ı ,ı ı ı ∏ ı ı ı ı ı ı ı ı ı ı ı ı ı ı ı ı ı ı ∏ ı 3.4

Our objective is then to get an estimator ł = (ı$_0$, ı$_1$..., ı$_k$) of $\boldsymbol{\beta}$ which maximizes the likelihood function. Since the likelihood equations are nonlinear in the parameters, the Newton-Raphson iterative maximum likelihood estimation method that expresses ł at the $(u+1)^{th}$ cycle of the iteration as:

ıł ı ı ı ı ıł ı ı ıı ıł ı ı ı ı ı ı ı 3.5

where, u= 0, 1, 2, 3 é , and ıı is a diagonal matrix with its diagonal elements,

ıł =*diag*[ı̂ (1- ı̂)]

Finally, ı¹ is the resultant maximum likelihood estimator of б with residual $R = P(Y=1|\ X)$ ī ıˆ (Collet, 1991; Greene, 1991). Newtonôs method usually converges to the maximum of the log-likelihood in just a few iterations unless the data are especially badly conditioned (Greene,1991).

3.3.2.2 Test of Goodness of Fit

Once a model has been developed, we would like to know how effective the model is in describing the outcome variable. This is referred to as goodness-of-fit. In testing the hypothesis that the model fits the data, the two common approaches are Pearsonôs X^2 statistic and the likelihood-ratio test (see details in Agresti, 1996).

The Hosmer-Lemeshow test is another alternative to check model fit. In this approach, data are divided into 10 groups. From each group, the observed and expected number of events will be computed. Then, the Hosmer-Lemeshow test statistic is given by

ı¹ ı ∑ ... 3.6

where $E_i = nP_i$, $V_i = nP_i\ (1- P_i\ )$, g is the number of group, O_i is observed number of events in the i^{th} group, E_i is expected number of events in the i^{th} group. If the observed number of events differs significantly from what is expected by the model, the statistic ıˆ will be large and there will be evidence against the null hypothesis that the model is adequate to fit the data. This statistic has an approximate chi-square distribution with (g-2) degrees of freedom.

If the calculated value of the Hosmer-Lemeshow goodness-of-fit test statistic is not significant, the model estimates are adequate to fit the data at an acceptable level.

The likelihood ratio (LR) test, which is defined as -2[*Lo* ï *L*$_1$*]* (where L_0 and L_1 are the maximized log-likelihoods under the null and alternative hypothesis, respectively) will be used to test the null hypothesis that the k-coefficients for the covariates in the model are not important in explaining the response variable against the alternative that at least one of the covariates is important. Under the null hypothesis, the LR is distributed as chi-square and if it is significant, we reject the null hypothesis and conclude that at least one of the k-covariates included in the model are important in explaining the variation in the outcome variable.

Test for a Single Predictor: The separate effects of each predictor variable in explaining the outcome variable was made by postulating the null hypothesis that: ¢ $_{o:}$ ϐ$_i$ = 0 against the alternative: ¢ $_1$: ϐ$_i$ Í 0, i = 1, 2é k for at least one i. The significance test for each coefficient in the model will be done using Wald chi-square. For a dichotomous independent variable, the Wald statistic (W) is:

$$1 \quad 1 \quad \frac{ł_1^{1}}{11 \quad 1\,1ł_1 1} \qquad 3.7$$

For large sample size this statistic has an approximate chi-square distribution with one degree of freedom. The Wald statistic, however, has some undesirable properties for large coefficients as the standard error is inflated lowering the Wald statistic (chi-square) value and leading to type II errors. On the other hand, Agresti (1996) suggested that the likelihood ratio (LR) test is more reliable for small sample sizes than the Wald test. Accordingly, this study will use the Wald and/or LR statistic to assess the significance of each predictor variable.

3.3.3 Multilevel Analysis

The 2011 EDHS data set used for this study is based on multistage stratified cluster sampling. The structure of data in the population is hierarchical, and a sample from such a population can be viewed as a multistage sample. For multistage clustered samples, the dependence among observations often comes from several levels of the hierarchy.

Multilevel analysis is a methodology for the analysis of data with complex patterns of variability, with a focus on nested sources of variability. These are used when the data structure is hierarchical with elementary units at level 1 nested in clusters at level 2, which in turn may be nested in (super) clusters at level 3, and so on. The latent variables, or random effects, are interpreted as unobserved heterogeneity at the different levels which induce dependence among all lower-level units belonging to a higher-level unit. Random intercepts represent heterogeneity between clusters in the overall response and random coefficients represent heterogeneity in the relationship between the response and explanatory variables.

The response variable in this study is ñthe status of childhood stuntingò which is binary and hence multilevel logistic regression model is a natural choice for modeling. Logistic regression requires the assumptions of independence of the observations conditional on the explanatory variables and uncorrelated residual errors. These assumptions are not always met when analyzing nested data. But the multilevel logistic regression analysis considers the variations due to hierarchy structure in the data. It allows the simultaneous examination of the effects of group level (cluster and division) and individual level variables on individual level outcomes while accounting for the non-independence of observations within groups. Also, this analysis allows the examination of both between group and within group variability as well as how group level and individual level variables are related to variability at both levels.

3.3.3.1 Multilevel Logistic Regression Model

3.3.3.1.1 Two-Level Model

In this study, the clustering of the data points within geographical regions offers a natural 2-level hierarchical structure of the data, i.e. children are nested within regions. Let y_{ij} be the binary outcome variable, coded ó0ô or ó1ô, associated with level-one unit i nested within level two unit j. Also let $ı_{11}$ be the probability that the response variable equals 1; $ı_{11}$ = Pr (y_{ij} = 1). Here, $ı_{11}$ follows a Bernoulli distribution. Like the logistic regression the $ı_{11}$ is modeled using the link function, logit. The two-level logistic regression model can be written as,

$$\log ı \frac{ı_{11}}{ı\,ı\,ı_{11}} ı\;ı\quad ı_{ı}\;ı\quad ı_{ı}\,ı_{11}\;ı\quad ı_{ıı} \qquad 3.8$$

where $ı_{ıı}$ is the random effect at level 2.

Therefore, conditional on $ı_{ıı}$, the y_{ij}ôs can be assumed to be independently distributed. Here, $ı_{ıı}$ is a random quantity and follows N $(0, ı_{ı}^{ı})$. The basic data structure of two-level logistic regression is a collection of N groups (units at level-two (regions)) and within group j (j=1, 2,é , N) a random sample of n_j level-one units. The outcome variable is dichotomous and denoted by $ı_{11}$ (i = 1,2,é ,n_j, j = 1,2,é ,N) for level-one unit i in group j.

Let the success probability in group j be denoted by $ı_{ı}$.The dichotomous outcome variable for the individual i in group j, $ı_{11}$; which is either 0 or 1 can be expressed as the sum of the probability in group j, $ı_{ı}$ (the average proportion of j levels in group j, E (y_{ij}) = $ı_{ı}$) plus some individual-dependent residual ı ıı , that is, ı ıı = ı ı + ı ıı the residual term is assumed to have mean zero but has a peculiar property that it can assume only the values ı ı and 1 ı ı . The variance of the residual is, Var (ı ıı) = ı ı ı 1 ı ı ı ı . Then we may have the following types of models.

3.3.3.1.2 The Empty Logistic Regression Model

This is the simplest case of hierarchical two level model for a dichotomous outcome variables in which there are no explanatory variables at all. This model only contains random groups and random variation within groups.

We focus on the model that specifies the transformed probabilities ı ıı ı ı to have a normal distribution. This is expressed, for a general link function ı ıı ı , by the formula

ı ıı ı ı ı ı ı ı ı ıı 3.9

where ı ı is the population average of the transformed probabilities and ı ıı the random deviation from this average for group j. If ı ıı ı is the logit function, then ı ıı ı ı is just the log-odds for group j. Thus, for the logit link function, the log-odds have a normal distribution in the population of groups, which is expressed by

ıı ı ıııı ı ı ı ı ı ı ı ıı. 3.10

For the deviations ı ıı it is assumed that they are independent random variables with a normal distribution with mean zero and variance ı ı ı .

This model does not include a separate parameter for the level-one variance. This is because the level-one residual variance of the dichotomous outcome variable follows directly from the success probability, as indicated by equation Var(ı ıı) = ı ı ı 1 ı ı ı ı . The probability corresponding to the average value ı ı , denoted by ı ı , is defined by ı ıı ı ı ı ı ı

For the logit function, the so-called logistic transformation of ı ı , is defined by

ı ı ı ıı ı ııı ı ı ı ı ı ı ı ı ıı ı ı / ı ı ııııı ı ı ı 3.11

Note that due to the non-linear nature of the logit link function, there is no a simple relation between the variance of the deviations ı ı ı . However, there is an approximate formula which is valid when the variances are small and is given by

ı ı ıı ı ı ı = ı ı ı ı 1 ı ı ı ıı ı ı ı ı 3.12

3.3.3.1.3 The Random Intercept Logistic Regression Model

In the random intercept logistic regression model the intercept is the only random effect meaning that the groups differ with respect to the average value of the response variable. But the relation between explanatory variables and the response can differ between groups in more ways.

The random intercept model expresses the log-odds, i.e. the logit of ı ıı , as a sum of a linear function of the explanatory variables. That is, since

ı ıı ı ı ı ı ı Σ ı ı ı ı ı ı ı ıı ı ı ı ı / ı ı ı ı ı ı Σ ı ı ı ı ı ı ı ıı ı ı ı ı , 3.13

ıı ı ıııı ıı ı ı ıı ı ı ı ıı / ı ı ı ıı ı ı ı ı ı ı ı ı ı ı ıı ı ı ı ı ıı ı ...ı ı ı ı ıı

ı ı ı ı ı Σ ı ı ı ı ı ı ı ıı 3.14

where the intercept term ı ı ı is assumed to vary randomly and is given by the sum of an average intercept ı ı and group-dependent deviations , ı ı ı that is

ı ı ı ı ı ı ı ı ı ı 3.15

3.3.3.1.4 The Random Coefficient Logistic Regression Model

This is used to assess whether the slope of any of the explanatory variables has a significant variance component between the groups. Now consider a model with group-specific regressions of logit of the success probability,

ıı ı ıııı ıı ı , on a single level-one explanatory variable X,

ıı ı ıııı ıı ı = ıı ı ı ı ıı / ı ı ı ıı ı = ı ı ı ı ı ı ı ı ı ıı 3.16

The intercepts ı ı ı as well as the regression coefficients, or slopes, ı ı ı are group-dependent.

These group-dependent coefficients can be split into an average coefficient and the group-dependent deviation

ı ı ı ı ı ı ı ı ı ı .

Substitution into (3.14) leads to the model

ıı ı ıııı ıı ı = ıı ı ı ı ıı / ı ı ı ıı ı = ı ı ı ı ı ı ı ı ı ı ıı ı + ı ı ı ıı ı ıı

= ı ı ı ı ı ı ıı ı ı ı ı ı ı ı ı ı ıı . 3.17

There are two random group effects, the random intercept ı ı ı and the random slope ı ı ı . It is assumed that the level-two residuals ı ı ı and ı ı ı have means zero given the value of the explanatory variable X. Thus ı ı is the average regression coefficient like ı ı is the average intercept. ı ı + ı ı ı ı ıı is called the fixed part of the model and the second part, ı ı ı ı ı ı ı ı ı ıı is called the random part.

These two group effects ı ı ı and ı ı ı will not be independent; they are rather correlated. Further, it is assumed that, for different groups, the pairs of random effects (ı ı ı , ı ı ı) are independent and identically distributed. Thus, the variances and covariance of the level-two random effects (ı ı ı , ı ı ı) are denoted as follows:

ı ı ı ı ı ı ı ı ı ı ı ı ı ı ı ı ı ı

ı ı ı ı ı ı ı ı ı ı ı ı ı ı ı ı ı ı

ı ı ı ı ı ı ı, ı ı ı ı ı ı ı ı

The model for a single explanatory variable discussed above can be extended by including more variables that have random effects. Suppose that there are k level-one explanatory variables ı ı, ı ı, ..., ı ı , and consider the model where all X-variables have varying slopes and random intercept. That is

ıı ı ıııı ıı ı = ıı ı ı (ı ıı / ı ı ı ıı) ı = ı ı ı ı ı ı ı ı ı ıı ı ı ı ı ı ı ıı ... ı ı ı ı ı ıı 3.18

3.3.3.2 Estimation and Testing Technique

The most common methods for estimating multilevel logistic models are based on likelihood. Among the methods, Marginal Quasi Likelihood or MQL [Goldstein (1991), Goldstein and Rasbash (1996)] and Penalized Quasi Likelihood or PQL [Laird (1978) and Breslow and Clayton (1993)] are the two prevailing approximation procedures. Both MQL and PQL are based on Taylor series expansion to achieve the approximation. Based on the usage of first and second term of Taylor expansion, MQL and PQL are often known as first-order MQL and second-order MQL, first-order PQL and second-order MQL respectively. After applying these quasi likelihood methods, the model is then estimated using iterative generalized least squares (IGLS) or reweighted IGLS (RIGLS) [Goldstein (2003)].

Parameter estimation in hierarchical generalized linear models is more complicated than the hierarchical linear models. The most frequently used kind of approximation method used are based on a first-order or second-order Taylor series expansion of the link function. In this study, the multilevel data analysis is supported by the software SAS.

CHAPTER FOUR

4. STATISTICAL DATA ANALYSIS AND RESULTS

The total number of children covered in the study is 8,487. Among these, 7583(89.3%) reside in rural areas whereas 904 (10.7%) reside in urban centers. The sample encompasses both male and female children of which, 4318 children (50.9 %) were males and 4169 children (49.1 %) were females.

4.1 Major demographic, socioeconomic, and health and environmental characteristics with stunting (H/A z-scores)

The major socioeconomic, demographic, health and environmental background characteristics of the respondents and children with stunting are presented in Table 4.1 below. The total number of children who are measured for anthropometric measurements of height for age is 8,487.

The proportion of stunted children, as can be seen in Table 4.1, differs by type of place of residence: urban and rural. Accordingly, more than eighty five percent of the stunted children (85.6 percent) reside in rural areas while a relatively smaller proportion of the stunted children (14.4 percent) reside in urban centers.

Moreover, the proportion of stunted children varied from one region to the other. For example, the highest prevalence of the stunted children was observed in Tigray (17.1 percent) followed by Ben-gumuz (15percent) as opposed to the lowest prevalence which was recorded in Addis Ababa (2.2 percent) and followed by Dire Dawa (5.6 percent).

Likewise, as Table 4.1shows, the proportion of stunted children varied by educational status of mothers. The highest proportion of the stunted children was observed for children whose mothers have no education (69.5 percent) as opposed to the lowest prevalence of the stunted children which was recorded for children whose mothers have secondary and above education level (5.1 percent). Additionally, highest prevalence (52.2 percent) of the stunted children was observed for children whose motherӧs husband/partners have no education as opposed to the lowest prevalence of child stunting which was recorded for children whose mothers husband/partner have secondary and above education level (11.4 percent).

Table 4.1also shows that the proportion of the children found stunted varies by the household economic status. The highest proportion of the stunted children was from poor households (49.7 percent) whereas the lowest proportion of the stunted children (17.1percent) was recorded from children residing in rich households.

With regards to child age, the highest proportion of stunted children was observed among those whose age group is less than 6 months (42.2 percent) as opposed to the smallest percentage (2 percent) of stunted children which was observed among those whose age group is 48-59months.

Table 4.1 Distribution of socioeconomic, demographic, and health and environmental related characteristics and stunting

Variables	Categories	Number of stunted children	percent	Total number of children
Sex of child	Female	1031	47.4%	4169
	Male	1146	52.6%	4318
Last Birth interval in month	0-24months	1258	57.8%	5632
	25-47 months	664	30.5%	2361
	48-59 months	255	11.7%	494
Age of child	<6 months	919	42.2%	1721

	6-11 months	604	27.7%	1844
	12-23 months	308	14.1%	1656
	24-35 months	179	8.2%	1550
	36-47 months	101	4.6%	1050
	48-59 months	66	2%	666
Birth order of the child	1	407	18. %7	1455
	2-3	704	32.3%	2674
	4-5	486	22.3%	2041
	6+	580	26.6%	2317
Motherǿs Education	No education	1514	69.5%	6156
	Primary education	553	25.4%	2069
	Secondary and above	110	5.1%	262
Employment status of mother	Unemployed	1512	69.5%	6012
	Employed	665	30.5%	2472
Wealth index	Poor	1082	49.7%	4559
	Medium	370	17%	1495
	Rich	725	33.3%	2433
Education of husband/ partner	No education	1137	52.2%	4621
	Primary education	791	36.3%	3173
	Secondary and above	249	11.4%	693
Number of household member	1-4	463	21.3%	2008
	5-9	1536	70.6%	5854
	10 and above	178	8.2%	625
Place of Residence	Rural	1864	85.6%	7583
	Urban	313	14.4%	904
Region	Tigray	373	17.1%	1416
	Afar	185	8.5%	833
	Amhara	232	10.7%	640
	Oromia	190	8.7%	977
	Somali	209	9.6%	585
	Ben-gumuz	327	15%	1302
	SNNP	213	9.8%	978
	Gambela	145	6.7%	784

	Harari	133	6.1%	403
	Addis Ababa	47	2.2%	139
	Dire Dawa	123	5.6%	430
Source of drinking water	Non improved source	1097	50.4%	4501
	improved source	1080	49.6%	3986
Had Diarrhea in the two weeks before survey	No	1938	89%	7137
	Yes	239	11%	1350
Had fever in the two weeks before survey	No	1834	84.2%	6785
	Yes	343	15.8%	1702
Type of toilet facility	No facilities	2042	93.8%	8098
	Have facilities	132	6.2%	389

4.2 Risk factors for stunting among under-five children:

Multiple logistic regression analysis

Multiple logistic regression analysis was applied to assess the effect of each selected variable on stunting, while controlling for other independent variables. The model is fitted to identify the basic demographic, socio-economic, and health and environmental determinants of stunting in under-five children in terms of long-run measures of health outcomes at the national level.

4.2.1 Determinants of stunting: multiple logistic regression results

Logistic regression analysis was performed to identify the effect of each explanatory variable on stunting. As can be seen in Tables 4.2a, 4.2b and 4.2c, the multiple logistic regression analysis identified, age of child, motherȏs educational level, wealth index, place of residence, had fever in the two weeks before survey, educational level of partner and geographical region are found to be significant determinants of stunting.

The logistic model showed that the likelihood of being stunted was highly significant for childrenøs aged less than five years. The risk of stunting for children in the age groups less than 6 months, 6-11 months, 12-23 months and 36-47 months are 12.311, 11.379, 9.65, 5.507 and 2.403 times the risk for children in the age group 48-59 months respectively.

The analysis also showed that children whose parents reside in rural areas were 22% less likely to be stunted when compared to those children whose parents reside in urban areas controlling for other variables in the model. The model also indicates that children whose parents reside in the Tigray, Benshangul-Gumuz, Amhara and Affar regions were 63.5%, 62.5%, 38.6% and 24.5% more likely to be stunted when compared with those from the reference category (Addis Ababa) respectively controlling for other variables in the model.

Motherøs educational level and partnerøs educational level are also significant factors associated with stunting. For instance, as compared to the reference category (secondary and above educational level), children whose mothers had no formal education and primary level of education were 98.3% and 80.7% more likely to be stunted respectively. Similarly, children whose father/partner had no formal education or only primary education level as compared to the reference category (secondary and higher education level) were 25.4% and 32.2% more stunted respectively controlling for other variables in the model.

Household wealth index also showed a statistical significant association with stunting. The likelihood of being stunted was 19% higher for children from poor families than those from the rich families controlling for other variables in the model. The model shows that the odds of stunting for children who had no fever in the two weeks before the survey date were 0.827 times the odds of stunting for children who had fever in the two weeks before the survey. In other words, children who had no fever are 17.3% less likely to be stunted than children who had fever in the two weeks before the survey controlling for other variables in the model.

After adjustment for other factors, the variables namely, sex of child, birth interval of the child, birth order of the child, household size, sources of drinking water, employment of mother, had diarrhea in the two weeks before survey and type of toilet facility appeared to have no significant effect on determining the status of stunting in under-five children.

Table 4.2 Multiple Regression Model results of H/A z-score (stunting)

Table 4.2a Summary of Stepwise Selection						
	Effect					
Step	Entered	Removed	DF	Wald Score Chi-Square	Pr > ChiSq	Variable Label
1	AGECH		5	1176.4731	<.0001*	Age of child
2	REGION		10	190.8589	<.0001*	Region
3	EDUM		2	54.5113	<.0001*	Education of mother
4	PRISD		1	13.1874	0.0003*	Type of place of residence
5	FEVER		1	6.7166	0.0096*	Had fever in last two weeks
6	WLIND		2	7.7897	0.0203*	Wealth index
7	EDUP		2	6.3682	0.0414*	Education of partner

* Significant (p<0.05)

Table 4.2b Analysis of Maximum Likelihood Estimates						
Covariate	**Category**	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept		1	1.0655	0.0651	267.8289	<.0001*
Region	**Tigray**	1	0.4708	0.0855	30.2888	<.0001*
	Affar	1	0.1980	0.0913	4.7073	0.0300*
	Amhara	1	0.3054	0.0839	13.2631	0.0003*
	Oromiya	1	-0.0145	0.0695	0.0433	0.8351
	Somali	1	-0.6046	0.0939	41.4791	<.0001*
	Benishangul-Gumuz	1	0.4643	0.0956	23.5983	<.0001*
	SNNP	1	0.1055	0.0735	2.0637	0.1508
	Gambela	1	-0.5746	0.0938	37.5497	<.0001*
	Harari	1	-0.3531	0.1125	9.8590	0.0017*
	Dire Dawa	1	0.0237	0.1985	0.0143	0.9049
Place of residence	**Rural**	1	-0.1241	0.0533	5.4082	0.0200*
Fever	**No**	1	-0.0947	0.0367	6.6615	0.0099*
Education level of	**No education level**	1	0.2591	0.0671	14.9084	0.0001*

Table 4.2b Analysis of Maximum Likelihood Estimates						
Covariate	**Category**	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
mother's	**secondary and above education level**	1	0.1663	0.0632	6.9196	0.0085*
Wealth index	**Poor**	1	0.1156	0.0413	7.8453	0.0051*
	Medium	1	-0.0568	0.0501	1.2857	0.2568
Education level of partner	**No education level**	1	0.1107	0.0465	5.6622	0.0173*
	secondary and above education level	1	0.0579	0.0510	1.2887	0.2563
Age of child	**<6 month**	1	0.8785	0.0934	88.4032	<.0001*
	6-11 month	1	0.7997	0.1131	49.9608	<.0001*
	12-23month	1	0.6350	0.0747	72.2209	<.0001*
	24- 35month	1	0.0741	0.0632	1.3727	0.2414
	36-47 month	1	-0.7553	0.0547	190.7367	<.0001*

* Significant (p<0.05)

Table4.2c Odds Ratio Estimates				
Covariate	**Category**	**Point Estimate**	**95% Wald Confidence Limits**	
Region	**Tigray vs Addis Ababa**	1.635	1.225	2.182
	Affar vs Addis Ababa	1.245	0.927	1.671
	Amhara vs Addis Ababa	1.386	1.044	1.841
	Oromiya vs Addis Ababa	1.007	0.771	1.314
	Somali vs Addis Ababa	0.558	0.414	0.752
	Benishangul-Gumuz vs Addis Ababa	1.625	1.201	2.198
	SNNP vs Addis Ababa	1.135	0.865	1.490
	Gambela vs Addis Ababa	0.575	0.425	0.777
	Harari vs Addis Ababa	0.717	0.517	0.995
	Dire Dawa vs Addis Ababa	1.046	0.649	1.686
Place of residence	**Rural vs Urban**	0.780	0.633	0.962
Fever	**No vs Yes**	0.827	0.717	0.955
Educational level of mother's	**No educational vs secondary and above educational level**	1.983	1.421	2.766
	primary educational level vs secondary and above educational level	1.807	1.307	2.498

Table4.2c Odds Ratio Estimates				
Covariate	**Category**	**Point Estimate**	**95% Wald Confidence Limits**	
Wealth index	**poor vs rich**	1.190	1.028	1.378
	medium vs rich	1.002	0.841	1.194
Educational level of partner's	**No educational vs secondary and above educational level**	1.254	0.996	1.579
	primary education level vs secondary and above education level	1.322	1.062	1.646
Age of child	**<6 month vs 48-59 month**	12.311	9.773	15.507
	6-11 month vs 48-59 month	11.379	8.624	15.013
	12-23month vs 48-59 month	9.650	8.000	11.641
	24- 35month vs 48-59 month	5.507	4.689	6.468
	36-47 month vs 48-59 month	2.403	2.091	2.761

4.2.2 Goodness of Fit

The diagnostic test results of the Hosmer-Lemeshow test presented in Appendix A reported chi-square value of 7.374 with p-value of 0.497 which is not significant showing that there is no difference between the observed and the model predicted values and hence estimates of the model adequately fit the data. Similarly, the deviance-based chi-square test provided chi-square value of ι^{1} = 8220.061, P<0.05 implying good fit for the combined model.

4.3 Risk factors for stunting among under-five children:

A Multi level logistic regression analysis

In the multilevel analysis, a two-level structure is used with regions as the second-level unit and children as the first-level unit. The nesting structure is children within regions that resulted in a set of 11 regions with a total of 8487 children. A chi-square test statistic was applied to assess heterogeneity between regions. The test yield ι^{1} = 8,220.061, P < 0.01. Thus, there is evidence for heterogeneity among regions with respect to stunting.

4.3.1 The empty logistic regression model

The empty model contains no explanatory variables and it can be considered as a parametric version of assessing heterogeneity among regions with respect to stunting in under-five children. The deviance-based Chi-square of an empty model without random effect (deviance = 9,664.57) and an empty model with random effect (deviance = 9,565.11) are presented in Tables 4.3a and 4.3b of Appendix B. This implies that an empty model with random effect is better than an empty model without random effect. In addition to this, the AIC value of an empty model without random effect (AIC = 9,666.57) is larger than that from the empty model with random effect (AIC = 9,569.11). This implies that an empty model for stunting with random effect is better than an empty model for stunting without random effect. The variance of the random factor in the empty model is significant which indicates that there are regional differences in the status of stunting (see Appendix B).

Table 4.4 Estimates for empty model

Fixed Part	Coefficient	S.E.	t- value	Pr > |t|
ı $_1$ = intercept	1.0101	0.09610	10.51	<.0001
Random Part	Variance Component	S.E.	t-value	P-value
Level-two variance ı $^1{}_1$ = ı ı ı ıı $_{1\,1}$)	0.09238	0.04328	2.13	0.0164
Deviance-based chi-square	9664.57			<.0001

* Statistically Significant at ($p<0.05$)

In Table 4.6 above the significant deviance-based chi-square value for the empty model implies that an empty model for stunting with random effect is better than an empty model for stunting without random effect.

4.3.2 The random intercept model and fixed explanatory variables

In order to identify the effect of some selected explanatory variables a multilevel logistic regression model with random intercept and fixed slope for explanatory variables were estimated with the help of SAS software. From Table 4.5 below, we observe that age of child, motherôs educational level, wealth index, educational level of partner, fever and place of residence were found to be significant determinants of variation in childhood stunting in under-five children among regions. The deviance based chi-square test for significance of random effects indicates that the random intercept model with the fixed slope is a better fit as compared to the empty model (see Appendix B).

Table 4.5 Estimates for random intercept and fixed coefficient model

Solutions for Fixed Effects						
Covariates	**Effect**	**Estimate**	**S.E.**	**DF**	**t Value**	**Pr > |t|**
Intercept		-1.0015	0.2812	10	-3.56	0.0052*
Place of residence	**Rural**	-0.2393	0.1084	9	-2.81	0.046*
	Urban (ref.)		.	.	.	.
Mother's employment	**No**	-0.01409	0.06208	10	-0.23	0.8250
	Yes (ref.)		.	.	.	.
Sex of child	**Male**	-0.1007	0.05476	10	-1.84	0.0959
	Female (ref.)		.	.	.	.
Fever	**No**	-0.1410	0.07750	10	-2.82	0.0488*
	Yes (ref.)		.	.	.	.
Educational level of mother's	**No education**	0.6483	0.1730	20	3.75	0.0013*
	Primary education	0.5584	0.1670	20	3.34	0.0032*
	Secondary and above(ref.)		.	.	.	.
Source of drinking water	**Non improved**	-0.00697	0.06028	9	-0.12	0.9105
	Improved(ref.)		.	.	.	.
Number of household member	**1-4**	0.1281	0.1271	20	1.01	0.3254
	5-9	0.04616	0.1073	20	0.43	0.6716
	10 and above(ref.)		.	.	.	.
Wealth index	**Poor**	0.1762	0.07709	19	2.29	0.0339*

Solutions for Fixed Effects						
Covariates	**Effect**	**Estimate**	**S.E.**	**DF**	**t Value**	**Pr > |t|**
	Medium	0.007465	0.08980	19	2.26	0.0446*
	Rich (ref.0		.	.	.	.
Husband/partner educational level	**No education**	0.2831	0.1121	20	2.53	0.0201*
	Primary education	0.2306	0.1180	20	1.95	0.0648
	Secondary and above(ref.)		.	.	.	.
Birth order of child	**1**	-0.01883	0.09955	30	-0.19	0.8513
	2-3	0.01642	0.07752	30	0.21	0.8337
	4-5	0.1106	0.07917	30	1.40	0.1727
	6+(ref.)		.	.	.	.
Had Diarrhea in the two weeks before survey	**No**	-0.1286	0.08885	10	-1.45	0.1784
	Yes(ref.)		.	.	.	.
Age of child	**<6 months**	2.5530	0.1244	50	20.52	<.0001*
	6-11 months	2.4575	0.1477	50	16.64	<.0001*
	12-23 months	2.2924	0.1051	50	21.81	<.0001*
	24-35 months	1.6944	0.09251	50	18.32	<.0001*
	36-47 months	0.8885	0.07898	50	11.25	<.0001*

Solutions for Fixed Effects						
Covariates	**Effect**	**Estimate**	**S.E.**	**DF**	**t Value**	**Pr > |t|**
	48-59 months(ref.)		.	.	.	.
Last Birth interval of the child	**0-24 months**	-0.1397	0.1146	20	-1.22	0.2370
	25-47 months	-0.06795	0.1213	20	-0.56	0.5817
	48-59 months(ref.)		.	.	.	.
Toilet facility	**No facility**	0.1875	0.1325	10	1.42	0.1873
	Have facility(ref.)		.	.	.	.

* Significant ($p<0.05$) ref. =reference category

4.3.3 The random coefficient model

The random coefficient model is useful because it shows how much variability exists at each level. The result is obtained by including level-2 random coefficients and an overall (level-2) or regional variance constant term ($ı^{1}{}_{1}$) together with variance and covariance terms representing the random effects of predictors.

In Table 4.6 below the estimated variance of intercept, slope of age of child and educational level of partnerǿs are region-wise intercepts. The slopes of the estimated variance of intercept and slope of age of child vary significantly, that is, there is a significant variation in the effects of these explanatory variables across the regions. But, the slope of educational level of partner is not significant; this implies that there is no significant variation of this explanatory variable across the region.

Table 4.6 Covariance Parameter Estimates					
Cov Parm	**Subject**	**Estimate**	**Standard Error**	**Z Value**	**Pr > Z**
Intercept	REGION	0.1146	0.05419	2.12	0.0172*
AGECH	REGION	0.00212	0.00023	9.23	0.0001*
EDUP	REGION	0.004747	0.009844	0.48	0.3148

Table 4.7 Level-2 covariance matrix

Level-2 variance Covariance	Estimated variance component	S.E.	Wald chi-square	P-value
1 1 1 1 1 1 1 1 1 1 1 1	8.235	0.853	93.2	0.0001*
1 1 1 1 1 1 1 1 1 1 1	0.422	0.053	63.398	0.0001*
1 1 1 1 1 1 1 1 1 1 1	0.194	0.183	1.124	0.2610
1 1 1 1 1 1 1 1 1 1 1 ,1 1 1 1	-1.803	0.206	76.605	0.0001*
1 1 1 1 1 1 1 1 1 1 1 ,1 1 1 1	-1.422	0.319	19.871	0.0001*
1 1 1 1 1 1 1 1 1 1 1 ,1 1 1 1	0.295	0.062	22.639	0.0001*

*Statistically Significant at (P<0.05)

In Table 4.7 above, the values of level-2 covariance matrix are obtained only from the estimated variance of intercept, slope of age of child and slope of educational level of husband/partner respectively.

Among those estimated variances, slope of educational level of partnerꞌs 1 1 1 1 1 is not significant, suggesting that the slope of educational level of partnerꞌs does not vary across the region, that is, there is only a significant variation in the effects of the intercept and age of child across the regions in terms of stunting.

Some of the variances of the interaction terms between intercepts and slopes of explanatory variables are also found significant. The significant deviance-based chi-square value indicated for the random coefficient model implies that the random coefficient model for stunting with random effect is a better fit as compared to the other models (see appendix B).

Table 4.8 Results for Fixed and Random Effects of Random Coefficient Model

	Solutions for Fixed Effects					
Covariates	**Effect**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
	Intercept	-1.0064	0.2818	10	-3.57	0.0051*
Place of Residence	**Rural**	-0.2375	0.1085	9	-2.19	0.0565
	Urban (ref.)		.	.	.	.
Mother's employment	**No**	-0.01328	0.06215	10	-0.21	0.8351
	Yes (ref.)		.	.	.	.
Sex of child	**Male**	-0.1007	0.05478	10	-1.84	0.0957
	Female (ref.)		.	.	.	.
Fever	**No**	-0.1414	0.07752	10	-1.82	0.0981
	Yes (ref.)		.	.	.	.
Educational level of mother's	**No education**	0.6464	0.1733	20	3.73	0.0013*
	Primary education	0.5539	0.1676	20	3.31	0.0035*

	Solutions for Fixed Effects					
Covariates	**Effect**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
	Secondary and above(ref.)		.	.	.	.
Source of drinking water	**Non improved**	-0.00744	0.06032	9	-0.12	0.9045
	Improved(ref.)		.	.	.	.
Number of household Member	**1-4**	0.1301	0.1272	20	1.02	0.3184
	5-9	0.04801	0.1074	20	0.45	0.6596
	10andabove(ref.)		.	.	.	.
Wealth index	**Poor**	0.1748	0.07726	19	2.26	0.0356*
	Medium	0.007046	0.08990	19	0.08	0.9383
	Rich (ref.0		.	.	.	.
Husband/partner educational Level	**No education**	.2872	0.1177	20	2.44	0.0241*
	Primary education	0.23890	0.1238	20	1.93	0.0680
	Secondary and above(ref.)		.	.	.	.
Birth order of child	**0= 1**	-0.01959	0.09959	30	-0.20	0.8454
	1= 2-3	0.01679	0.07755	30	0.22	0.8301

Covariates	Solutions for Fixed Effects					
	Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
	2= 4-5	0.1105	0.07920	30	1.40	0.1732
	3= 6+(ref.)		.	.	.	.
Had Diarrhea in the two Weeks before survey	**No**	-0.1283	0.08888	10	-1.44	0.1793
	Yes(ref.)		.	.	.	.
Age of child	**0= <6 months**	2.5535	0.1244	50	20.52	<.0001*
	1= 6-11 months	2.4593	0.1478	50	16.64	<.0001*
	2= 12-23 months	2.2915	0.1051	50	21.80	<.0001*
	3= 24-35 months	1.6956	0.09259	50	18.31	<.0001*
	4= 36-47 months	0.8889	0.07902	50	11.25	<.0001*
	5= 48-59 months(ref.)		.	.	.	.
Last Birth	**0-24 months**	-0.1396	0.1147	20	-1.22	0.2376

	Solutions for Fixed Effects					
Covariates	**Effect**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
interval of the child	**25-47 months**	-0.06703	0.1214	20	-0.55	0.5869
	48-59 months(ref.)		.	.	.	.
Toilet facility	**No facility**	0.1841	0.1330	10	1.38	0.1963
	Have facility(ref.)		.	.	.	.

*Statistically Significant at (P<0.05), (Ref.) = indicates the reference category

The fixed part of Table 4.8 above shows that education status of mother, education status of husband/partner, age of child and wealth index are jointly statistically significant explanatory variables on stunting.

CHAPTER FIVE

5 DISCUSSION, CONCLUSIONS AND RECOMMEDATIONS

In this chapter we discuss the main findings in this study and also present the conclusions drawn and recommendations made.

5.1 DISCUSSION

This study is an attempt to identify the determinants of stunting in under-five children based on Ethiopian Demographic and Health Survey (EDHS 2011) data. Accordingly descriptive analysis, multiple logistic regression and multilevel logistic regression techniques were used.

At the beginning the study included the most important predictor variable that were categorized under socio-economic, demographic and health and environmental characteristics. Concerning the regional disparity children in Tigray, Benshangul-Gumuz, Amhara and Affar are at a higher risk of stunting than children who live in Addis Ababa. The observed higher risk of malnutrition in Tigray, Amhara and Benshangul-Gumuz regions may be attributed to differences in cultural and dietary practices (Woldemariam and Timotiwos, 2002).

The result of the present study indicates that age of child is also one of the important determinant factors of stunting of under-five children in Ethiopia. The prevalence of stunting was higher in children aged less than 6 months than the other age groups. This finding is different from the findings of two previous studies conducted by Kabubo-Mariara et al. (2009) and Shrimpton et al. (2001), which revealed a rapid fall in childrenôs height from birth to 59 months; although stunting continues after 24 months. This could be as a result of weaning and lower breast milk intakes, which make them prone to childhood stunting.

The risk of stunting is significantly higher for children whose mothers have no education and primary education level than children whose mothers have secondary and higher level of education. This finding seemed to be consistent with other studies (Oyekale and Oyekale, 2000; Smith and Haddad, 2000). They indicated that education improves the ability of mothers to implement simple health knowledge and facilitates their capacity to manipulate their environment including health care facilities, interact more effectively with health professionals, comply with treatment recommendations, and keep their environment clean. Furthermore, educated women have greater control over health choices for their children. The result of the current study is also congruous with a study done in Bangladesh. The analysis of that study indicated that the educational level of caregiver was positively related to the better nutritional status of children. This is likely to be attributed to better education because educated mothers are more conscious about their childrenÕs health; they tend to look after their children in a better way (Rayhan and Hayat, 2006).

Rahman et al (2009)made a study based on the experience of 63 developing countries over 25-years period to identify the determinants of child malnutrition for each developing region. Six factors were explored; one of the important factors was womenÕs education. They depicted that improvements in female secondary school enrollment rates were estimated to be responsible for 43% of the total 15.5% reduction in the child malnutrition rate of developing countries during the period 1970-95 (Rahman et al, 2009). In addition, the percentage of stunting amongst fathers with low educational levels was the highest, whereas fathers who are illiterate have stunted children in a percentage much higher than those of higher educational level. The percentage of stunting in fewer than three children is relatively identical regarding fathers with preliminary educational level. This fact may be related to inability of illiterate or of low educational level fathers to meet his children nutritional needs, because of the low income, and increase in the percentage of unemployment fathers.

In addition, our study revealed that under-five children from poor households are at a higher risk of stunting than children from rich households. This finding is consistent with other studies (Smith et al., 2005; Woldemariam and Timotewos, 2002).They indicated that better off households have better access to food and higher cash incomes than poor households, allowing them a quality diet, better access to medical care and more money to spend on essential non-food items such as schooling, clothing and hygiene products.

The findings of this study also show that children who had no fever two weeks before date of survey are significantly vulnerable to stunting than those who had not. This finding is consistent with other studies (Sommerfelt et. al., 1994; WHO, 1986).

This study examined individual and community-level (regional) factors as significant determinants of childhood stunting in under-five children. It confirms the importance of region-wise variations with respect to childhood stunting.

Using multilevel logistic regression method of analysis, this study allowed variations in childhood stunting among geographical regions. The model suggests that the status of stunting of children differs among regions, although the variations among different communities/regions with respect to the odds of having childhood stunting were found to originate mainly from variations in individual-level factors. These findings are consistent with most studies that have tried to differentiate contextual effects from compositional effects (Frohlich et al. 2002; Subrama-nian et al. 2003) and support a major role for community-level phenomenon as a strong influence on childhood stunting.

5.2 CONCLUSION

The study identified the following socio-economic, demographic and health and environmental variables as important determinants of stunting of under-five children in Ethiopia:

Age of child, motherȏs educational level, wealth index, place of residence, had fever in the two weeks before survey, educational level of partner and geographical region.

5.3 RECOMMEDATIONS

The findings from this study have some relevant policy implications.

- There is a clear need for intervention to reduce economic inequalities and ultimately poverty among the populace.
- Adult literacy programs with special focus on child health and nutrition should be organized particularly for women in communities with a high illiteracy rate as a short-term solution aimed at increasing low literacy level in Ethiopia.
- Any intervention by governmental and non-governmental organizations that aim at improving under-five children nutritional status should consider regions with a high rate of childhood stunting so as to avert under-coverage of the regions that deserve it.

References `

Abdeljawad, H. M. and Humeid J. M. S. (2008). ñNutritional Status of Palestinian Children under Five (6 - 59 months) in Three Governorates of the Gaza Stripò. This paper presented on 27 Oct, 2008 in Siege and Mental Health é Walls vs. Bridges at http://www.gcmhp.net.

Agresti, A. (1996): An Introduction to Categorical Data Analysis. John Wiley and Sons Inc., Singapore.

Breslow, N. E. and D. G. Clayton (1993) Approximate inference in generalized linear mixed models. J. Am. Statist. Assoc.

Cobham David P. and Kanafani Noman. (2004).The economics of Palestine: economic policy and institutional reform for a viable Palestinian state. P.301

Collet, D. (1991): Modeling Binary Data. Chapman & Hall, London.

Collins English Dictionary. 2003. Complete and Unabridged 6th Edition.

Copas, J.B. (1988): Binary Regression Models for Contaminated Data. *Journal of Royal Statistical Association*, B 50 (2).

EDHS (2005). Ethiopian Demographic and Health Survey. Addis Ababa

EDHS (2011). Ethiopian Demographic and Health Survey. Addis Ababa

Freedman David S., Thornton John C., Mei Zuguo, Wang Jack, Dietz William H., Pierson Jr Richard N., and Horlick Mary. (2005). ñHeight and Adiposity among Childrenò. *Obesity research journal.*vol.12; P.846_835.

Frohlich K.L., Potvin L., Gauvin L. & Chabot P. (2002) Youth smoking initiation: disentangling context from composition. Health & Place 8, 155ï 166. Available from.

Genebo Timotiows and Girma Woldemariam. (2002).ñDeterminants of Nutritional Status of Women and Children in Ethiopiaò. ORC Macro, Calverton, Maryland USA. P. 1-36. (Assessed at http://www.measuredhs. com- nutrition.pdf dated May 22nd, 2007).

Greene, W. H. (1991): Econometric Analysis. 2nd Edition. New York, Macmillan.

Goldstein, H., (1991). Nonlinear multilevel models with an application to discrete response data. Biometrika, 78:45ï 51.

Goldstein, H. (1995). Multilevel Statistical Models. London: Edward Arnold/New York: Halsted.

Goldstein, H. and J. Rasbash., (1996) Improved approximations for multilevel models with binary responses. J. Roy. Statist. Soc. A.

Goldstein, H., Multilevel Statistical Models. 3rd edition (2003) London: Arnold; New York: Oxford University Press Inc.

Hosmer, D. and S. Lemeshow (1989): Applied Logistic Regression. John Wiley and Sons, Inc.

Hosmer, W.D. and S. Lemeshow (2000), Applied Logistic Regression. 2nd Ed., John Wiley and Sons, New York.

Kabubo-Mariara J., Ndenge G.K. & Mwabu D.K.(2009) Determinants of childrenôs nutritional status in Kenya: evidence from demographic and health surveys. *Journal of African Economies* 18, 363ï 387.

Kikafunda Joyce K.,Walker Ann F., Collett David and Tumwine James K. (1998). ñRisk factors for early childhood malnutrition in Ugandaò. *Official journal of the American academy of pediatrics*.Vol.102; P.1_ 8.

Lang Susan S. (May 29, 1998). ñStunted growth affects almost 40 percent of the developing world's infants". Cornell news.P-30.

http://www.news.cornell.edu/releases/May98/stunting.ssl.html

Lewit Eugene M., Kerrebrock Nancy. (1997). ñPopulation based growth stuntingò. The future of children.Vol.7, no.2; P.149_156.

Maddala, G.S. (1997): Introduction to Econometrics. Second Edition. Prentice-Hall, Inc., USA.

Maja, P., Mateja, B., and Sandra, T. (2004). Comparison of Logistic Regression and Linear Discriminant Analysis: A Simulation Study. Metodoloski, Vol.1.

Mamabolo Ramoteme L, Alberts Marianne, Steyn Nelia P, Delemarre-van de Waal Henriette A and Levitt Naomi S. (2005). ñPrevalence and determinants of stunting and overweight in 3 -year-old black South African children residing in the Central Region of Limpopo Province, South Africaò. *Journal of public health nutrition*. Volume 8, P. 501_508.

Md. Hasinur Rahaman Khan and J. Ewart H. Shaw.(2009). ñMultilevel Logistic Regression Analysis Applied to Binary Contraceptive Prevalence Dataò. *Journal of Data Science* 9(2011), 93-110.

Michaelsen Kim F, Hoppe Camilla, Roos Nanna, KÊstel Pernille, Stougaard Maria, Lauritzen Lotte, M -lgaard Christian, Girma Tsinuel, Friis Henrik. (2008). ñChoice of Foods and Ingredients for Moderately Malnourished Children 6 Months to 5 Years Oldò. Background paper presented at http://www.who.int/nutrition/publications/en/. P. 9.

Nandi Biplab K. (July 1999). ñNutritional Security; Asian Perspective Beyond 2000ò. Food and Agriculture Organization of the United Nations. P. 20_51. http://www.fao.org/docrep/005/AC622E/AC622E00.htm.

Olivieri, F., Semproli, S., Pettener, D., & Toselli, S. (2008). ñGrowth and malnutrition of rural Zimbabwean children (6-17 years of age)ò.*American Journal of Physical Anthropology*.Vol. 136, Issue 2, P. 214 ñ 222.

Onis M. de, Monteiro C., AkrÈ J. and Clugston G. (1993). ñThe worldwide magnitude of protein-energy malnutritionò. Bulletin of the World Health Organization. Vol. 71, P. 703-712.

Oyekale, A. S.and Oyekale, T. O. (2000). Do Motherôs Education Levels Matter in Child Malnutrition and Health Outcomes in Gambia and Niger, Department of Agricultural Economic, University of Ibadan, Nigeria.

Padmadas Sabu S, Hutter Inge and Willekens Frans. ñWeaning initiation patterns and subsequent linear growth progression among children aged 2 and 4 years in Indiaò. (2002). *International Journal of Epidemiology.*Vol.31. P.855_863.

Rahman Mosiur, Mostofa Golam and Nasrin Sarker Obaida. (2009). ñNutritional status among children aged 24-59 months in rural Bangladeshò. *The Internet Journal of Biological Anthropology.* Vol. 3, No.1.

Rayhan Israt and Hayat Khan Sekander. (2006). ñFactors Causing Malnutrition among under Five Children in Bangladeshò. *Pakistan Journal of Nutrition.* Volume 5, P. 558-562.

Ricci Judith A and Becker Stan. (1996). ñRisk factors for wasting and stunting among children in Metro Cebu, Philippinesò. *American journal of clinical nutrition.* Vol. 63. P. 966-975.

Rice Amy L., Sacco Lisa, Hyder Adnan, and Black Robert E. (2000). ñMalnutrition as an underlying cause of childhood deaths associated with infectious diseases in developing countriesò. Bulletin of the World Health Organization. Vol.78, No.10: P. 1207-1221.

Rolfes Sharon Rady, Pinna Kathryn, and Whitney Ellie. (2004). ñUnderstanding Normal and Clinical Nutritionò. National academic of Sciences. 7th edition. P. 522_534.

Semba Richard D, de Pee Saskia, Sun Kai, Sari Mayang, Akhter Nasima, and Bloem Martin W. (2008). ñEffect of parental formal education on risk of child stunting in Indonesia and Bangladeshò. *The Lancet journal*, Vol. 371, P. 322-328.

Scrimshaw Nevin S. (1998). ñMalnutrition, brain development, learning, and behaviorò. *Science Direct journal.* Vol. 18, No. 2; P. 351-379.

Shaikh S, Mahalanabis D, Chatterjee S, Kurpad A V and Khaled M A (2003). ñLean body mass in preschool aged urban children in India: gender differenceò. European *Journal of Clinical Nutrition.* Vol. 57, P. 389ñ393.

Shrimpton R., Victora C.G., de O.M., Lima R.C., Blossner M. & Clugston G. (2001) Worldwide timing of growth faltering: implications for nutritional interventions. Pediatrics 107, E75. Available from.

Shrimpton Roger and Kachondham Yongyout. (2003). ñAnalyzing the Causes of Child Stuntingò. P. 4-8.

Smith, L.C. and Haddad, L. (2000).Explaining Child Malnutrition in Developing Countries: A Cross-Country Analysis.ò IFPRI Research Report 111. Washington D.C. International Policy Research Institute.

Simondon KB, Costes A, Delaunay V, Diallo A, Simondon F. (2001). ñChildren's height, health and appetite mothers' weaning decisions in rural Senegalò.*International Journal of Epidemiology.* Vol.30.

Solomon Amsalu and Zemene Tigabu. (2008). ñRisk factors for severe acute malnutrition in children under the age of fiveò. *Ethiop Journal of Health Dev.* Vol. 22, P. 21_25.

Sommerfelt, A. Elizabeth, and S. Kathryn (1994). Childrenôs nutritional status. DHS Comparative Studies No. 12.Calverton, Maryland, USA: Macro International Inc.

Subramanian S.V., Lochner K.A. and Kawachi I. (2003) Neighborhood differences in social capital: a compositional artifact or a contextual construct. Health & Place 9, 33ï44. Available from.

Tabachnick, G.B. and Fidell, S.L. (1996). Using Multivariate Statistics. Harper Collins College Publishers: New York.

Turyashemererwa F.M., Kikafunda J.K., and Agaba E. (2009). ñPrevalence of early childhood malnutrition and influencing factors in peri urban areas of kabarole district, western Ugandaò. *African Journal of food agriculture, Nutrition, and development*.Vol. 9, P.

United Nations Childrenôs Fund (UNICEF) (2007). The State of the Worldôs Children 2007: Women and Children. UNICEF, New York.

Veronicah Kirogo, Kogi-Makau Wambui, and Muroki Nelson M. (2007). ñThe role of irrigation on improvement of nutrition status of young children central Kenyaò. *African Journal of Food Agriculture Nutrition and Development.* Vol. 7, No. 2; P.1-16.

Victora Cesar G, Adair Linda, Fall Caroline, Hallal Pedro C, Martorell Reynaldo, Richter Linda, and Sachdev Harshpal Singh. (2008). ñMaternal and child under nutrition: consequences for adult health and human capitalò. The lancet Series. P. 23_40.

Woldemariam Girma and Timotiows Genbo (2002). Determinants of the Nutritional Status of Mother s, and Children in Ethiopia. Calverton, Maryland, USA: ORC Macro.

World Health Organisation (WHO) Multicentre Growth Reference Study Group (2006) WHO Child Growth Standards based on length/height, weight and age. Acta Paediatrica Supplement 450, 76ï 85.

Website: http://www.emro.who.int/nutrition/malnutrition.htm, (2007).

APPENDIX A

SAS OUTPUT FOR MULTIPLE LOGISTIC REGRESSION

Summary of Stepwise Selection

Step	Effect Entered	Effect Removed	DF	Wald Chi-Square Score	Pr > Chi Sq	Variable Label
1	AGECH		5	1176.4731	<.0001*	Age of child
2	REGION		10	190.8589	<.0001*	Region
3	EDUM		2	54.5113	<.0001*	Education of mother
4	PRISD		1	13.1874	0.0003*	Type of place of residence
5	FEVER		1	6.7166	0.0096*	Had fever in last two weeks
6	WLIND		2	7.7897	0.0203*	Wealth index
7	EDUP		2	6.3682	0.0414*	Education of partner

*Significant (p<0.05)

Type 3 Analysis of Effects			
Effect	**DF**	**Wald Chi-Square**	**Pr > ChiSq**
Region	10	152.2617	<.0001*
Place of residence	1	5.4082	0.0200*

Type 3 Analysis of Effects			
Effect	**DF**	**Wald Chi-Square**	**Pr > ChiSq**
Fever	1	6.6615	0.0099*
Educational level of mother's	2	16.2845	0.0003*
Wealth index	2	7.8666	0.0196*
Education of partner	2	6.3566	0.0417*
Age of child	5	1044.0810	<.0001*

*Significant (p<0.05)

Analysis of Maximum Likelihood Estimates						
Parameter	**Category**	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept		1	1.0655	0.0651	267.8289	<.0001*
Region	**Tigray**	1	0.4708	0.0855	30.2888	<.0001*
	Affar	1	0.1980	0.0913	4.7073	0.0300*
	Amhara	1	0.3054	0.0839	13.2631	0.0003*
	Oromiya	1	-0.0145	0.0695	0.0433	0.8351
	Somali	1	-0.6046	0.0939	41.4791	<.0001*
	Benishangul-Gumuz	1	0.4643	0.0956	23.5983	<.0001*
	SNNP	1	0.1055	0.0735	2.0637	0.1508
	Gambela	1	-0.5746	0.0938	37.5497	<.0001*
	Harari	1	-0.3531	0.1125	9.8590	0.0017*
	Dire Dawa	1	0.0237	0.1985	0.0143	0.9049

Analysis of Maximum Likelihood Estimates						
Parameter	**Category**	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Place of residence	**Rural**	1	-0.1241	0.0533	5.4082	0.0200*
Fever	**No**	1	-0.0947	0.0367	6.6615	0.0099*
Education level of mother's	**No education level**	1	0.2591	0.0671	14.9084	0.0001*
	secondary and above education level	1	0.1663	0.0632	6.9196	0.0085*
Wealth index	**Poor**	1	0.1156	0.0413	7.8453	0.0051*
	Medium	1	-0.0568	0.0501	1.2857	0.2568
Education level of partner	**No education level**	1	0.1107	0.0465	5.6622	0.0173*
	secondary and above education level	1	0.0579	0.0510	1.2887	0.2563
Age of child	**<6 month**	1	0.8785	0.0934	88.4032	<.0001*
	6-11 month	1	0.7997	0.1131	49.9608	<.0001*
	12-23month	1	0.6350	0.0747	72.2209	<.0001*
	24- 35month	1	0.0741	0.0632	1.3727	0.2414
	36-47 month	1	-0.7553	0.0547	190.7367	<.0001*

*Significant (p<0.05)

	Odds Ratio Estimates			
Covariate	**Effect**	**Point Estimate**	**95% Wald Confidence Limits**	
Region	**Tigray vs Addis Ababa**	1.635	1.225	2.182
	Affar vs Addis Ababa	1.245	0.927	1.671
	Amhara vs Addis Ababa	1.386	1.044	1.841

	Odds Ratio Estimates			
Covariate	**Effect**	**Point Estimate**	**95% Wald Confidence Limits**	
	Oromiya vs Addis Ababa	1.007	0.771	1.314
	Somali vs Addis Ababa	0.558	0.414	0.752
	Benishangul-Gumuz vs Addis Ababa	1.625	1.201	2.198
	SNNP vs Addis Ababa	1.135	0.865	1.490
	Gambela vs Addis Ababa	0.575	0.425	0.777
	Harari vs Addis Ababa	0.717	0.517	0.995
	Dire Dawa vs Addis Ababa	1.046	0.649	1.686
Place of residence	**Rural vs Urban**	0.780	0.633	0.962
Fever	**No vs Yes**	0.827	0.717	0.955
Educational level of mother's	**No educational vs secondary and above educational level**	1.983	1.421	2.766
	primary educational level vs secondary and above educational level	1.807	1.307	2.498
Wealth index	**poor vs rich**	1.190	1.028	1.378
	medium vs rich	1.002	0.841	1.194
Educational level of partner's	**No educational vs secondary and above educational level**	1.254	0.996	1.579
	primary education level vs secondary and above education level	1.322	1.062	1.646
Age of child	**<6 month vs 48-59 month**	12.311	9.773	15.507
	6-11 month vs 48-59 month	11.379	8.624	15.013
	12-23month vs 48-59 month	9.650	8.000	11.641
	24- 35month vs 48-59 month	5.507	4.689	6.468

	Odds Ratio Estimates			
Covariate	**Effect**	**Point Estimate**	**95% Wald Confidence Limits**	
	36-47 month vs 48-59 month	2.403	2.091	2.761

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	75.7	**Somers' D**	0.518
Percent Discordant	23.9	**Gamma**	0.521
Percent Tied	0.5	**Tau-a**	0.198
Pairs	13736870	**C**	0.759

Omnibus Tests of Model Coefficients

		Chi-square	Df	Sig.
Step 1	Step	1444.505	35	.000
	Block	1444.505	35	.000
	Model	1444.505	35	.000

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	8220.061[a]	.157	.230

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	Df	Sig.
1	7.374	8	.497

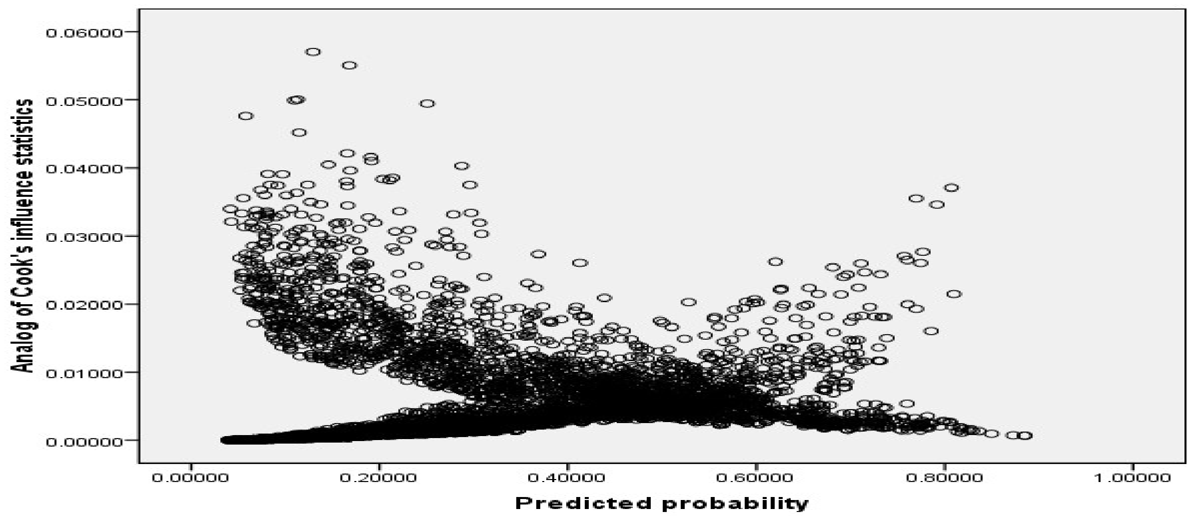
Result of diagnostic tests for outliers and influential value

Descriptive Statistics

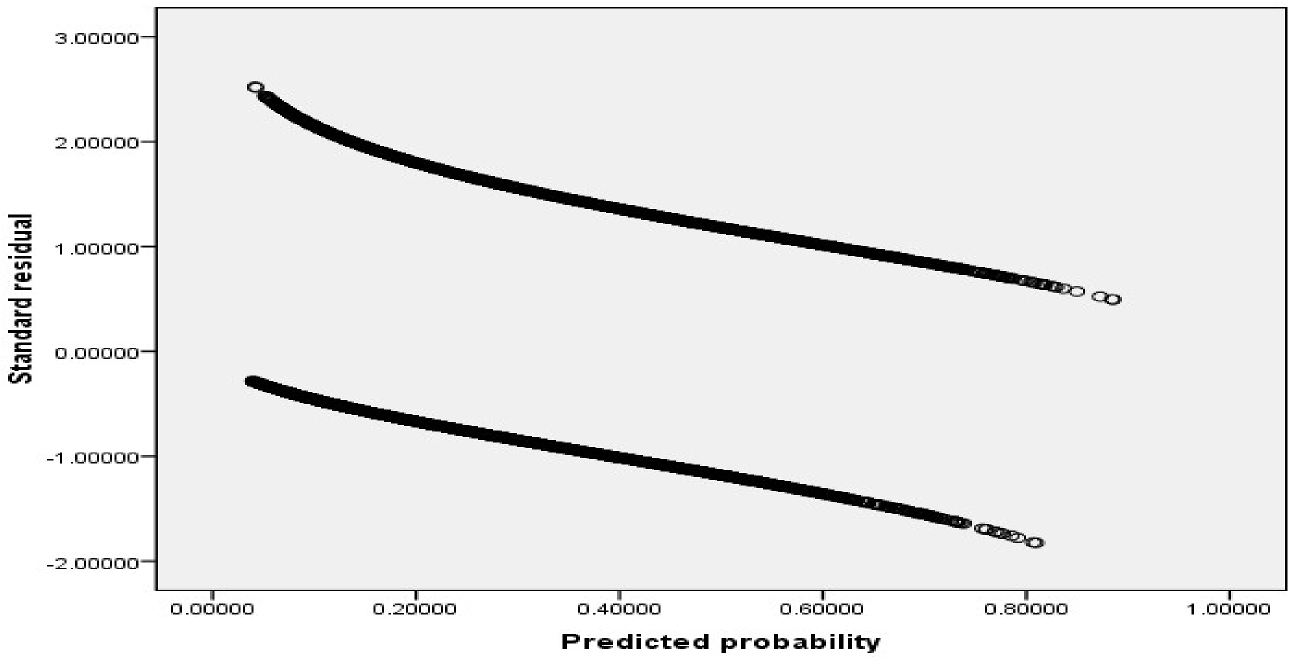
	N	Minimum	Maximum
DFBETA for constant	8487	-.03153	.02806
DFBETA for V024(1)	8487	-.01358	.00973
DFBETA for V024(2)	8487	-.01361	.00913
DFBETA for V024(3)	8487	-.01322	.00903
DFBETA for V024(4)	8487	-.01347	.00898
DFBETA for V024(5)	8487	-.01397	.00919
DFBETA for V024(6)	8487	-.01379	.01013
DFBETA for V024(7)	8487	-.01380	.00917
DFBETA for V024(8)	8487	-.01495	.01098
DFBETA for V024(9)	8487	-.01365	.01237
DFBETA for V024(10)	8487	-.02690	.03692
DFBETA for V025(1)	8487	-.00736	.01016
DFBETA for V714(1)	8487	-.00334	.00253
DFBETA for B4(1)	8487	-.00167	.00160
DFBETA for H22(1)	8487	-.00511	.00367
DFBETA for EDUM(1)	8487	-.02333	.01792
DFBETA for EDUM(2)	8487	-.02257	.01739
DFBETA for SORDW(1)	8487	-.00279	.00262
DFBETA for NHHM(1)	8487	-.01326	.01001
DFBETA for NHHM(2)	8487	-.01018	.00758
DFBETA for WLIND(1)	8487	-.00549	.00442
DFBETA for WLIND(2)	8487	-.00491	.00472
DFBETA for EDUP(1)	8487	-.01114	.00914
DFBETA for EDUP(2)	8487	-.00989	.00807
DFBETA for BIRON(1)	8487	-.00602	.00786
DFBETA for BIRON(2)	8487	-.00420	.00370
DFBETA for BIRON(3)	8487	-.00384	.00409
DFBETA for DIARRHEA(1)	8487	-.00712	.00557
DFBETA for AGECH(1)	8487	-.00420	.01187
DFBETA for AGECH(2)	8487	-.00665	.01782
DFBETA for AGECH(3)	8487	-.00374	.00809

DFBETA for AGECH(4)	8487	-.00339	.00555
DFBETA for AGECH(5)	8487	-.00286	.00345
DFBETA for BIRINCH(1)	8487	-.00622	.00758
DFBETA for BIRINCH(2)	8487	-.00601	.00703
DFBETA for TOILET(1)	8487	-.01619	.01288
Valid N (listwise)	**8487**		

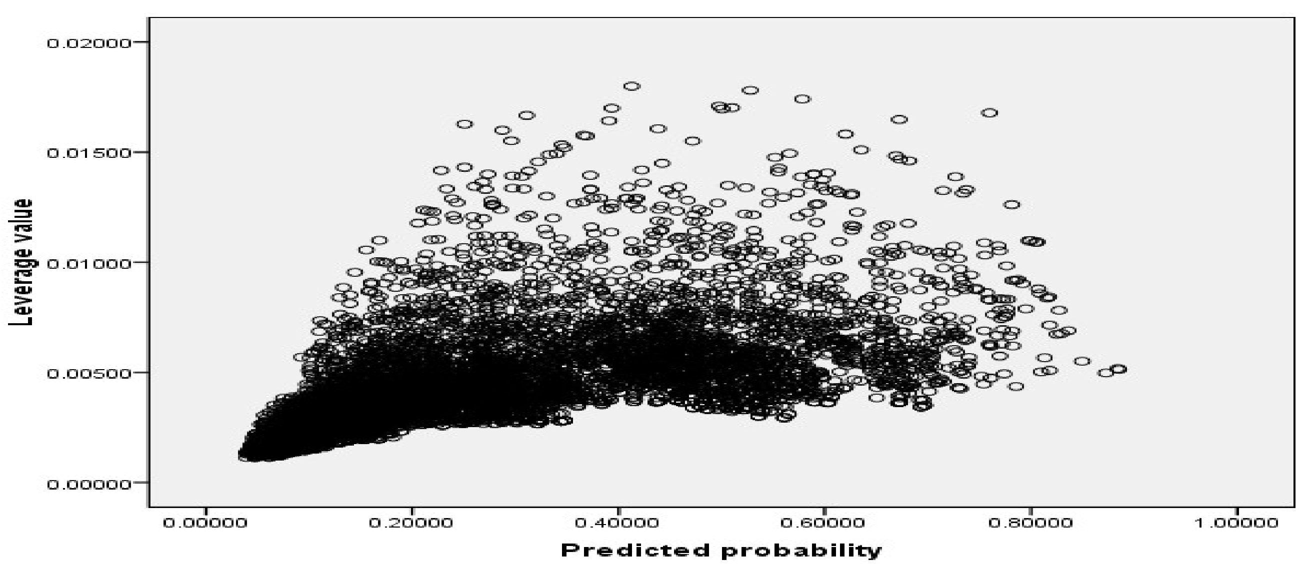
Change in analog of cook's influence statistics against Predicted probabilities



Change in Deviance against Predicted probabilities



Change in leverage value against Predicted probabilities



Appendix B

SAS OUTPUT FOR MULTILEVEL LOGISTIC REGRESSION

A, Empty model

a, empty model without random effect

Fit Statistics	
-2 Log Likelihood	9664.57
AIC (smaller is better)	9666.57
AICC (smaller is better)	9666.57
BIC (smaller is better)	9673.61
CAIC (smaller is better)	9674.61
HQIC (smaller is better)	9668.97
Pearson Chi-Square	8487.00
Pearson Chi-Square / DF	1.00

Parameter Estimates					
Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	1.0642	0.02486	8486	42.81	<.0001

b, empty model with random effect

Fit Statistics	
-2 Log Likelihood	9565.11
AIC (smaller is better)	9569.11
AICC (smaller is better)	9569.11
BIC (smaller is better)	9569.90
CAIC (smaller is better)	9571.90
HQIC (smaller is better)	9568.60

Fit Statistics for Conditional Distribution	
-2 log L(DEP | r. effects)	9526.94
Pearson Chi-Square	8455.61
Pearson Chi-Square / DF	1.00

Covariance Parameter Estimates					
Cov Parm	**Subject**	**Estimate**	**Standard Error**	**Z Value**	**Pr > Z**
Intercept	Region	0.09238	0.04328	2.13	0.0164

Solutions for Fixed Effects					
Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	1.0101	0.09610	10	10.51	<.0001

Solution for Random Effects						
Effect	**Subject**	**Estimate**	**Std Err Pred**	**DF**	**t Value**	**Pr > |t|**
Intercept	Tigray	0.3842	0.1195	8486	3.21	0.0013
Intercept	Affar	0.2265	0.1204	8486	1.88	0.0600
Intercept	Amhara	0.2522	0.1176	8486	2.14	0.0320
Intercept	Oromiya	0.01750	0.1098	8486	0.16	0.8733
Intercept	Somali	-0.3912	0.1223	8486	-3.20	0.0014
Intercept	Benishangul-Gumuz	0.4338	0.1254	8486	3.46	0.0005
Intercept	SNNP	0.07891	0.1113	8486	0.71	0.4784
Intercept	Gambela	-0.4150	0.1203	8486	-3.45	0.0006
Intercept	Harari	-0.2691	0.1325	8486	-2.03	0.0422
Intercept	Addis Ababa	-0.2501	0.1738	8486	-1.44	0.1502
Intercept	Dire Dawa	-0.08493	0.1322	8486	-0.64	0.5207

Tests of Covariance Parameters Based on the Likelihood					
Label	**DF**	**-2 Log Like**	**ChiSq**	**Pr > ChiSq**	**Note**
No G-side effects	1	9664.57	99.46	<.0001	MI

MI: P-value based on a mixture of chi-squares.

B, Random intercept with fixed slope model

Fit Statistics	
-2 Log Likelihood	8259.74
AIC (smaller is better)	8313.74
AICC (smaller is better)	8313.92
BIC (smaller is better)	8324.48
CAIC (smaller is better)	8351.48
HQIC (smaller is better)	8306.97

Fit Statistics for Conditional Distribution	
-2 log L(DEP | r. effects)	8220.87
Pearson Chi-Square	8393.34
Pearson Chi-Square / DF	0.99

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
Intercept	Region	0.1172	0.05413	2.16	0.0152

Solutions for Fixed Effects						
Covariates	**Effect**	**Estimate**	**S.E.**	**DF**	**t Value**	**Pr > |t|**
	Intercept	-1.0015	0.2812	10	-3.56	0.0052*
Place of residence	**Rural**	-0.2393	0.1084	9	-2.81	0.046*
	Urban (ref.)	0	.	.	.	.
Mother's employment	**No**	-0.01409	0.06208	10	-0.23	0.8250
	Yes (ref.)	0	.	.	.	.
Sex of child	**Male**	-0.1007	0.05476	10	-1.84	0.0959
	Female (ref.)	0	.	.	.	.
Fever	**No**	-0.1410	0.07750	10	-2.82	0.0488*
	Yes (ref.)	0	.	.	.	.
Educational level of mother's	**No education**	0.6483	0.1730	20	3.75	0.0013*
	Primary education	0.5584	0.1670	20	3.34	0.0032*
	Secondary and above(ref.)	0	.	.	.	.
Source of drinking water	**Non improved**	-0.00697	0.06028	9	-0.12	0.9105
	Improved(ref.)	0	.	.	.	.
Number of house hold member	**1-4**	0.1281	0.1271	20	1.01	0.3254
	5-9	0.04616	0.1073	20	0.43	0.6716
	10 and above(ref.)	0	.	.	.	.
Wealth index	**Poor**	0.1762	0.07709	19	2.29	0.0339*
	Medium	0.007465	0.08980	19	2.26	0.0446*
	Rich (ref.0	0	.	.	.	.
partner's educational level	**No education**	0.2831	0.1121	20	2.53	0.0201*
	Primary education	0.2306	0.1180	20	1.95	0.0648

Solutions for Fixed Effects						
Covariates	**Effect**	**Estimate**	**S.E.**	**DF**	**t Value**	**Pr > |t|**
	Secondary and above(ref.)	0	.	.	.	.
Birth order of child	**0= 1**	-0.01883	0.09955	30	-0.19	0.8513
	1= 2-3	0.01642	0.07752	30	0.21	0.8337
	2= 4-5	0.1106	0.07917	30	1.40	0.1727
	3= 6+(ref.)	0	.	.	.	.
Had Diarrhea in the two Weeks before survey	**No**	-0.1286	0.08885	10	-1.45	0.1784
	Yes(ref.)	0	.	.	.	.
Age of child	**0= <6 months**	2.5530	0.1244	50	20.52	<.0001*
	1= 6-11 months	2.4575	0.1477	50	16.64	<.0001*
	2= 12-23 months	2.2924	0.1051	50	21.81	<.0001*
	3= 24-35 months	1.6944	0.09251	50	18.32	<.0001*
	4= 36-47 months	0.8885	0.07898	50	11.25	<.0001*
	5= 48-59 months(ref.)	0	.	.	.	.
Last Birth interval of the child	**0-24 months**	-0.1397	0.1146	20	-1.22	0.2370
	25-47 months	-0.06795	0.1213	20	-0.56	0.5817
	48-59 months(ref.)	0	.	.	.	.

Solutions for Fixed Effects						
Covariates	**Effect**	**Estimate**	**S.E.**	**DF**	**t Value**	**Pr > |t|**
Toilet facility	**No facility**	0.1875	0.1325	10	1.42	0.1873
	Have facility(ref.)	0	.	.	.	.

Type III Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
place of residence	1	9	4.88	0.0467*
Employment of mother	1	10	0.05	0.8250
Sex of child	1	10	3.38	0.0159*
Fever	1	10	3.31	0.0988
Education of mother	2	20	7.04	0.0049*
Source of drinking water	1	9	0.01	0.9105
Number of house hold member	2	20	0.68	0.5180
Wealth index	2	19	3.67	0.0449*
Education of partner	2	20	3.25	0.0401*
Birth order of child	3	30	0.90	0.4523
Diarrhea	1	10	2.09	0.1784
Age of child	5	50	169.64	<.0001*
Birth interval of child	2	20	1.04	0.3701
Toilet	1	10	2.00	0.1873

*Significant($p<0.05$)

Solution for Random Effects						
Effect	**Subject**	**Estimate**	**Std Err Pred**	**DF**	**t Value**	**Pr > |t|**
Intercept	Tigray	0.4441	0.1327	8461	3.35	0.0008
Intercept	Affar	0.1960	0.1360	8461	1.44	0.1496
Intercept	Amhara	0.2709	0.1313	8461	2.06	0.0392
Intercept	Oromiya	-0.01423	0.1239	8461	-0.11	0.9086
Intercept	Somali	-0.5422	0.1392	8461	-3.89	<.0001
Intercept	Benishangul-Gumuz	0.4045	0.1387	8461	2.92	0.0036
Intercept	SNNP	0.08604	0.1259	8461	0.68	0.4943
Intercept	Gambela	-0.5515	0.1385	8461	-3.98	<.0001
Intercept	Harari	-0.3142	0.1493	8461	-2.10	0.0353
Intercept	Addis Ababa	0.02458	0.1988	8461	0.12	0.9016
Intercept	Dire Dawa	-0.01915	0.1477	8461	-0.13	0.8969

Tests of Covariance Parameters Based on the Likelihood					
Label	**DF**	**-2 Log Like**	**ChiSq**	**Pr > ChiSq**	**Note**
No G-side effects	1	8367.47	107.73	<.0001*	MI

*Significant (p<0.05)

C, Random coefficient model

Fit Statistics	
-2 Log Likelihood	8259.39
AIC (smaller is better)	8315.39
AICC (smaller is better)	8315.59
BIC (smaller is better)	8326.53
CAIC (smaller is better)	8354.53
HQIC (smaller is better)	8308.37

Fit Statistics for Conditional Distribution	
-2 log L(DEP | r. effects)	8214.95
Pearson Chi-Square	8384.50
Pearson Chi-Square / DF	0.99

Covariance Parameter Estimates					
Cov Parm	**Subject**	**Estimate**	**Standard Error**	**Z Value**	**Pr > Z**
Intercept	REGION	0.1146	0.05419	2.12	0.0172*
AGECH	REGION	0.00212	0.00023	9.23	0.0001*
EDUP	REGION	0.004747	0.009844	0.48	0.3148

*Significant (p<0.05)

Results for Fixed and Random Effects of Random Coefficient Model

	Solutions for Fixed Effects					
Covariates	**Effect**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
	Intercept	-1.0064	0.2818	10	-3.57	0.0051*
Place of residence	**Rural**	-0.2375	0.1085	9	-2.19	0.0565
	Urban (ref.)	0	.	.	.	.
Mother's employment	**No**	-0.01328	0.06215	10	-0.21	0.8351
	Yes (ref.)	0	.	.	.	.
Sex of child	**Male**	-0.1007	0.05478	10	-1.84	0.0957
	Female (ref.)	0	.	.	.	.
Fever	**No**	-0.1414	0.07752	10	-1.82	0.0981
	Yes (ref.)	0	.	.	.	.
Educational level of mother's	**No education**	0.6464	0.1733	20	3.73	0.0013*
	Primary education	0.5539	0.1676	20	3.31	0.0035*
	Secondary and above(ref.)	0	.	.	.	.
Source of drinking water	**Non improved**	-0.00744	0.06032	9	-0.12	0.9045
	Improved(ref.)	0	.	.	.	.
Number of house hold member	**1-4**	0.1301	0.1272	20	1.02	0.3184
	5-9	0.04801	0.1074	20	0.45	0.6596
	10 and above(ref.)	0	.	.	.	.

	Solutions for Fixed Effects					
Covariates	**Effect**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Wealth index	**Poor**	0.1748	0.07726	19	2.26	0.0356*
	Medium	0.007046	0.08990	19	0.08	0.9383
	Rich (ref.0	0	.	.	.	.
partner's educational level	**No education**	.2872	0.1177	20	2.44	0.0241*
	Primary education	0.23890	0.1238	20	1.93	0.0680
	Secondary and above(ref.)	0	.	.	.	.
Birth order of child	**0= 1**	-0.01959	0.09959	30	-0.20	0.8454
	1= 2-3	0.01679	0.07755	30	0.22	0.8301
	2= 4-5	0.1105	0.07920	30	1.40	0.1732
	3= 6+(ref.)	0	.	.	.	.
Had Diarrhea in the two Weeks before survey	**No**	-0.1283	0.08888	10	-1.44	0.1793
	Yes(ref.)	0	.	.	.	.
Age of child	**0= <6 months**	2.5535	0.1244	50	20.52	<.0001*
	1= 6-11 months	2.4593	0.1478	50	16.64	<.0001*
	2= 12-23 months	2.2915	0.1051	50	21.80	<.0001*

	Solutions for Fixed Effects					
Covariates	**Effect**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
	3= 24-35 months	1.6956	0.09259	50	18.31	<.0001*
	4= 36-47 months	0.8889	0.07902	50	11.25	<.0001*
	5= 48-59 months(ref.)	0	.	.	.	.
Last Birth interval of the child	**0-24 months**	-0.1396	0.1147	20	-1.22	0.2376
	25-47 months	-0.06703	0.1214	20	-0.55	0.5869
	48-59 months(ref.)	0	.	.	.	.
Toilet facility	**No facility**	0.1841	0.1330	10	1.38	0.1963
	Have facility(ref.)	0	.	.	.	.

*Significant(p<0.05)

Type III Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Place of residence	1	9	4.79	0.0565
Employment of mother	1	10	0.05	0.8351
Sex of child	1	10	3.38	0.0957

Type III Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Fever	1	10	3.33	0.0981
Educational level of mother	2	20	6.98	0.0050*
Source of drinking water	1	9	0.02	0.9045
Number of house hold member	2	20	0.69	0.5129
Wealth index	2	19	3.61	0.0470*
Educational level of partner	2	20	2.99	0.0733
Birth order of child	3	30	0.90	0.4518
Diarrhea	1	10	2.09	0.1793
Age of child	5	50	169.58	<.0001*
Birth interval of child	2	20	1.05	0.3678
Toilet	1	10	1.92	0.1963

*Significant (p<0.05)

Level-2 covariance matrix

Level-2 variance Covariance	Estimated variance component	S.E.	Z-value	P-value
1 1 1 1 1 1 1 1 1 1 1 1	8.235	0.853	93.2	0.0001*
1 1 1 1 1 1 1 1 1 1 1 1	0.422	0.053	63.398	0.0001*
1 1 1 1 1 1 1 1 1 1 1 1	0.194	0.183	1.124	0.2610
1 1 1 1 1 1 1 1 1 1 1 , 1 1 1 1	-1.803	0.206	76.605	0.0001*
1 1 1 1 1 1 1 1 1 1 1 , 1 1 1 1	-1.422	0.319	19.871	0.0001*
1 1 1 1 1 1 1 1 1 1 1 , 1 1 1 1	0.295	0.062	22.639	0.0001*

*Statistically Significant at (P<0.05)

Tests of Covariance Parameters Based on the Likelihood				
Label	**DF**	**-2 Log Like**	**Chi-Sq**	**Pr > ChiSq**
No G-side effects	2	8367.47	108.08	<.0001

*Significant (p<0.05)