

ADDIS ABABA UNIVERSITY  
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ANALYSIS OF RISK FACTOR CORRELATED WITH CHILD MALNUTRITION IN  
ETHIOPIA AND MODELING THE PROGRESSION OF MALNUTRITION WITH  
CHILD AGE

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This is to certify that the thesis prepared by Mesay Tefera, entitled: Analysis of Risk Factor Correlated with Child Malnutrition in Ethiopia and Modeling the Progression of Malnutrition With Child Age: A Panel Data Analysis of Young Lives Data and submitted in partial fulfillment of the requirements for the Degree of Master of Science in Development Economics complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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## **DECLARATION**

I, the undersigned, declare that the thesis is my original work, has not been presented for degrees in any other University and all sources of materials used for the thesis have been duly acknowledged.

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## ABSTRACT

Although the problem of malnutrition affects the entire population, children are more vulnerable because it hinders their optimal physical growth, cognitive and socio-emotional development. Undernutrition is associated with 45 percent of deaths of under 5 children. The solution for this serious public health issue is essential. From this perspective, this study aimed to identify the risk factor correlated with malnutrition and to examine the progression of malnutrition as child grows from his/her 1<sup>st</sup> to 15<sup>th</sup> birthday. The data for the study were taken from the Young Lives panel data for Ethiopia. To achieve objectives of the study, two malnutrition indicators (stunting and thinness) were studied. These indicators were examined independently due to their biological differences. Statistical models that handle the complexities of the panel data and transitional probability were employed. Marginal GEE Model, Generalized Mixed Effect Ordered Logistic Model and Markov Transitional Model used for analysis. The findings of the study revealed that sex of child, child age in month; mother education level, wealth index and number of drought animal own by household were found significant determinant factors of stunting. On the other hand, sex of child, child age in month, region, wealth index, number of drought animal own by household and number of small ruminant animal own by household were found significant determinant factor for thinness. Markov Transitional model analysis indicated that female children had the higher probability of recovering from both stunting and thinness than their male counterpart. To reduce child malnutrition, some curtail steps regards educating mothers and improving economic situation of population should be considered.

**Keywords:** Stunting, Thinness, Panel Data Analysis, and Marginal GEE Model, Generalized Mixed Effect Ordered Logistic Model and Markov Transitional Model.

## ACRONYMS

AIC	Akaike Information Criterion
AOR	Adjusted Odds Ratio
BMI	Body Mass Index
COHA	Cost of Hunger in Africa
CDC	Centers for Disease Control and Prevention
CSA	Central Statistics Agency
EDHS	Ethiopian Demographic and Health Survey
GEE	Generalized Estimating Equation
GLM	Generalized Linear Model
GLMM	Generalized Linear Mixed Model
GLMM	Generalized Linear Mixed Model
QIC	Quasi-likelihood Information Criterion Quasi
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WFP	World Food Program
WHO	World Health Organization
YL	Young Lives

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# CHAPTER ONE

## INTRODUCTION

### 1.1. Backgrounds of the Study

Adequate nutrition is vital in early childhood to ensure healthy growth, proper organ development and function, a strong immune system, neurological and cognitive improvement. Economic growth and human development require well-nourished populations who can learn new skills, think critically and contribute to their communities [16,54].

About 47 million under five children are wasted, 14.3 million are severely wasted and 144 million are stunted, while 38.3 million are overweight worldwide. Around 45% of deaths among children under five years of age are linked to undernutrition. These mostly happen in low- and middle-income countries. Similarly, rates of childhood overweight and obesity are mounting in these countries.

[106]

Ethiopia is one of the low-income countries where child malnutrition continues to be a serious problem. Countrywide, 38 percent and 18 percent of children under age of five are stunted, and severely stunted respectively. Likewise 10 percent and 3 percent of under five children are wasted and severely wasted respectively. About 24 percent of children are underweight, and 7 percent are severely underweight [22], which is one of the most serious public health problem in Ethiopia.

Even though several studies have examined the risk factors correlated with child malnutrition in Ethiopia, their conclusions about child malnutrition are either drawn from cross-sectional studies or their focuses were on under - five children. Fewer have used longitudinal data analysis for instance [13], used longitudinal analysis to examine the dynamics of stunting in Ethiopia. Consequently, there

is considerable lack of evidence regarding the child malnutrition progression and risk factor correlated with child malnutrition (in terms of stunting and thinness) as child's grown up from early childhood to adolescence in Ethiopia setting. Therefore this study examined risk factor correlated with child malnutrition and modeling its progression across the children age.

This study was conducted by using Ethiopian Young Lives data. The Young Lives Survey data are hierarchical and longitudinal in nature i.e. repeated measure (level 1) nested within individuals' children (level-2) and individual children are nested within sentinel site (level 3). This rise questions on the efficiency of models that assume independence of observations and calls for a statistical model that takes this correlated nature of the data into account. In the study, to come up with solutions to above stated problem, Marginal Models and Multilevel Mixed Effect Ordered Logistic Model were fitted to Analysis the risk factors correlated with child malnutrition and Transitional Probability Model were fitted to estimate gender specific the progression of malnutrition across child age. The procedural steps of these models will be discussed in chapter three of this work.

## **1.2. Statement of the Problem**

In Ethiopia, child malnutrition continues to be a main public health problem. According to the Demographic and Health Survey (DHS) of Ethiopia, national prevalence of chronic malnutrition has remained severe despite a reduction from 51% in 2005 to 38% in 2016 [22]. The levels of wasting and underweight have also declined over the same period. Nevertheless, the level of child malnutrition is still intolerably higher than the world average [22]. Furthermore, Ethiopia was ranked as the 16<sup>th</sup> and 33<sup>th</sup> in the prevalence of stunting and wasting [44]. While, under-five children are the most vulnerable age group for malnutrition, the effect of child malnutrition is long lasting and goes

beyond childhood. For example, malnutrition during early age reduces the educational attainment and labor productivity and increases the risk of chronic illnesses in later age [72,76,104].

Though several studies have examined the risk factor correlated with child malnutrition in Ethiopia most of them focus on under-five (that ignores beyond five years child's malnutrition status history) and /or school aged children (that ignores the under five child's malnutrition status history) and rely depend on cross-sectional designs which makes it difficult to understand the progression of child malnutrition across the child age and its proximate risk factor. Therefore this study aimed to fill these research gaps by analyzing the risk factor correlated with two child malnutrition indicators (stunting and thinness) and examines the gender specific progression of these two indicators as child growth from his/her 1<sup>st</sup> to 15<sup>th</sup> birthday.

### **1.3. Research Questions**

- i. What are the important risk factors correlated child malnutrition in Ethiopia?
- ii. How gender of child affects the progression of malnutrition across the child's age?

### **1.4. Objectives of the Study**

#### General Objective

The general objective of this study is to identify the proximate risk factor correlated with child malnutrition and to examine the progression of malnutrition as child grows from his/her 1<sup>st</sup> to 15<sup>th</sup> birthday.

#### Specific Objectives

- i. To examine the trends of the severity of malnutrition as child grows from his/her 1<sup>st</sup> to 15<sup>th</sup> birthday.
- ii. To identify the longitudinal correlate of malnutrition as child grow-up to his/her 15<sup>th</sup> birthday

- iii. To examine gender specific progression of malnutrition as child grow-up to his/her 15<sup>th</sup> birthday

### **1.5. Significance of the Study**

Several studies done to explore the determinant for under-five child malnutrition in Ethiopia have identified a range of factors that contribute to malnutrition. But very few of these studies gave attention to malnutrition for children beyond five-years old. This study focused in identifying the most important risk factor correlated with malnutrition and examining the progression of malnutrition as the child growth from his/her 1<sup>st</sup> to 15<sup>th</sup> birthday.

- i. This finding will be helpful for better understanding of the important risk factor correlated with child malnutrition as well as gender specific progression of malnutrition in Ethiopia
- ii. This study will be helpful for the formulation of policies and strategies towards risk factor correlated child malnutrition and progression of malnutrition across child age.
- iii. Finally, the findings and conclusion for this study can be used as the basis for further research on the area of progression and correlate of child malnutrition form early childhood to adolescence.

### **1.6. Scope of the Study**

The present study uses the constructed Young Lives data which is an observational panel study of roughly 12,000 children in Ethiopia, India, Peru, and Vietnam. Two cohorts of children, a younger and an older, were enrolled and tracked in each country. This study only examines 1,999 children from the younger cohort, who were enrolled in 2002 at 1 years of age and followed up to their 15 year of age in 2016.

### **1.7. Limitation of the Study**

Young Lives is not anticipated to be a countrywide representative survey such as the Demographic and Health Survey or Welfare Monitoring Survey. Rather, as a longitudinal study, it is anticipated to show changes for individuals over time and the impact of earlier circumstances on children's later outcomes, shedding light on the differences between age, language, gender, location, wealth index and more [108]. Therefore the result of this study not anticipated to represent the national picture of child malnutrition in Ethiopia.

### **1.8. Organization of the Paper**

The rest of the paper is organized as follows. Chapter two contains both theoretical and empirical literature reviews on child malnutrition. Chapter three describes the methodological issues of the study and chapter four gives the results and interpretations. Finally, discussions conclusions and recommendations of the study are presented in chapter five.

## CHAPTER TWO

### LITERATURE REVIEW

In this chapter, we will present a review of both theoretical and empirical literatures on correlate of child malnutrition. Relevant studies were reviewed giving special focus on findings and methodological issue in developing countries.

#### 2.1 Theoretical Literature Review

##### 2.1.1. Introduction

The term malnutrition generally refers to both under nutrition and overnutrition. But in Ethiopia only three percent of under-five children are over weighted [22]. Therefore; this study focused on undernutrition which is an important health issue of the country.

##### 2.1.2 Types of Malnutrition

Malnutrition can appear as either overweight/obesity or undernutrition (including micronutrient deficiency) or. Overweight/obesity occurs when a person has too much body fat and weighs more than would be expected for a healthy person of the same height, putting his/her health at risk. Undernutrition is a result of inadequate nutrient intake and/or absorption, and/or illness or disease. Under nutrition increases the risk of illness and death. About 45 percent of deaths of children under five are attributable to various forms of under nutrition [17].

This is because poor nutrition impairs a person's immune system, making him/her more susceptible to illness and infections and less likely to recover. In addition, under nutrition, particularly early in life, hinders optimal physical growth and cognitive, motor, and socio-emotional development, which may in turn lead to short- and long-term impacts on learning and productivity [37]. The major types

of undernutrition, which can occur alone or in combination, are acute malnutrition (wasting, thinness, and/or bilateral pitting edema), chronic under nutrition (stunting), underweight (a composite of stunting and wasting), and micronutrient deficiencies (e.g., deficiencies in vitamin A, iodine, iron, and zinc). Micronutrient deficiencies are assessed using biochemical and clinical methods not by anthropometric measurements and are therefore not addressed in this study.

### **2.1.3 Nutrition from Birth to Five Years of Age**

Good nutrition, adequate health care, and a nurturing environment all contribute to children reaching their full growth and development potential. This is especially important during the 1,000 days from the beginning of the mother's pregnancy to the child's second birthday, when children are growing and developing most rapidly. To support this growth, young children have relatively high nutritional needs and are more vulnerable to malnutrition and its consequences than other age groups. Malnourished children are at higher risk of illness and death than well-nourished children; undernutrition is associated with 45 percent of deaths of under five children [17]. In addition, nutritional deficits during this period can have lifelong and often irreversible consequences, including impaired cognitive development, lower school performance and achievement, reduced economic productivity, and increased risk of certain chronic diseases in adulthood [92]. While undernutrition in developing countries remains a problem, at the same time, the worldwide increase in infant and childhood overweight and obesity also has both short and long term consequences. Overweight and obese children are at higher risk of developing diabetes, high blood pressure, respiratory problems, and of being obese in adulthood, with the associated increased risks of non communicable disease, disability, and premature death [105]. Preventing and treating malnutrition in young children can substantially reduce deaths and ensure that children grow optimally, both

physically and mentally. Children in this age group, particularly under the age of two, are very responsive to nutrition interventions, making this a critical period to act [20].

#### **2.1.4 Nutrition during Childhood and Adolescence 5 - 19 Years**

Children and adolescents 5-19 years of age have high nutritional needs because they are growing rapidly. This is especially true for adolescents (10 - 19 years of age), whose growth can be as rapid as that of infants [85]. Adolescent boys and girls have higher calorie and nutrient needs than any other age group with boys needing more overall calories to meet the demands of growth spurts and the onset of puberty [74, 85]. Meeting these needs can be particularly challenging in poor and food insecure environments. Undernutrition in this age group can delay sexual maturation, slow growth [74, 84], and reduce a child/adolescent's ability to learn, lowering school performance and achievement [37]. Meanwhile overweight and obesity at this age are likely to persist into adulthood and increase the risk of chronic disease in the short and long term [23]. There is also evidence that obesity may be related to early puberty in girls and delayed puberty in boys [21]. In addition, pregnancy and lactation during adolescence can negatively impact a girl's nutritional status by stunting the girl's growth and lowering her nutritional stores as her needs compete with those of the fetus, increasing risk of pregnancy complications [71,].

Malnutrition can also affects pregnancy outcomes in adolescent girls. Underweight adolescents face higher risk of complications such as preterm birth and delivering a child with low birth weight, while overweight/obese adolescents are more likely to suffer preeclampsia and gestational diabetes and to require cesarean delivery [48,50]. These complications have been found to contribute to the intergenerational cycle of malnutrition [46].

### **2.1.5 Measuring Child and Adolescent Malnutrition**

Malnutrition is commonly measured using the World Health Organization Child Growth standard [102] for children from birth to 5 years and WHO Growth Reference [103] for children and adolescent 5–19 years. These use a reference population of healthy children to compare a child's anthropometric measurements with the median for children of the same sex and age from the reference population. The difference between the value for an individual and the median value of the reference population, divided by the standard deviation of the reference population, are referred to as z-scores. Using height-for-age, BMI-for-age, and weight-for-height z-scores, respectively, it is possible to assess a child's condition compared to the reference population. When z-scores are between -3 and -2 standard deviations, the child can be described as moderately malnourished, while if they are below -3 standard deviations it can be described as severely malnourished.

### **2.1.6 Why Does Malnutrition Matter for Economic Development?**

Good nutrition is essential for the health, growth, development, and economic well-being of individuals and populations. Malnutrition is a serious public health issue that contributes to high rates of maternal and child illness and mortality. In addition, malnourished individuals are less likely to achieve their full potential in terms of education and economic productivity, and they earn less income than well-nourished peers, making it difficult to break the cycle of poverty [51]. When a high proportion of a population is malnourished, it weakens the entire economy, potentially reducing a country's gross domestic product (GDP) by as much as 3 percent [98]. Addressing malnutrition is essential to promote development, and measuring nutritional status is crucial to identifying individuals who need nutritional care and support and to monitoring the nutrition situation of a population.

### **2.1.7 Why Gender Matters in malnutrition?**

Despite their vulnerability to malnutrition, women are in a unique position to improve nutrition in their households. They are responsible for growing, purchasing, processing and preparing most of

the food which is consumed. Yet vulnerable women, especially those in female-headed households, frequently have limited access to nutrition information and the resources they need to improve food security, such as income, land, equipment, financial services and training. Gender matters because initiatives to improve nutrition cannot achieve lasting success without taking into consideration the social, economic and biological differences between men and women and, in particular, the gender inequalities which stand in the way of good nutrition. FAO has found that projects which promote gender equality and the empowerment of women significantly improve nutrition and well-being for the entire household

## **2.2 Empirical Literature Review**

A study on social and economic impacts of child under nutrition in Ethiopia shows more than two out of every five children in Ethiopia are stunted [24]. The annual costs associated with child undernutrition are estimated at Ethiopian birr (ETB) 55.5 billion, which is equivalent to 16.5% of the country's GDP. Eliminating stunting in Ethiopia is a necessary step for growth and transformation [24]. Several risk factors correlated with child malnutrition based studies done in various places are reviewed below.

### **Sex of Child**

Sex of the child is one of the important risk factor for child malnutrition. Several studies found that mothers prefer to offer better nutrients to sons due to societal preference mapping. A similar result was observed from West Bengal through a study by [78]. The authors examined the nutritional status of children less than 5 years of age in the two villages of Sahajapur and Kuchli. The study showed a remarkably high incidence of undernourishment and deprivation, even of the 'severe' and 'disastrous' types, in girls in comparison with boys. Interestingly, the village with the better overall nutritional record had much sharper sex discrimination against girls. The economic benefits of land

reform in Kuchli seem to have primarily benefited boys, not girls. The nutritional conditions of girls were broadly similar in the two villages. Overall nutritional status is better for Kuchli than for Sahajapur. This is attributed to the better nutritional condition of the boys, proving a clear sex bias. On the other hand, a study conducted in Botswana shows all the prevalent for the three types of malnutrition (stunting, wasting and underweight) were higher among boys than among girls [73].

### **Age of Child**

A cumulative indicator of growth retardation (height-for-age) in children is positively associated with age [12]. Local and regional studies in Ethiopia have also shown the possibility of being malnourished increases with age of the child [34,109].

### **Place of Residence**

According to Ghosh A. (2011) because of an urban lifestyle and lack of physical activity, urban children, irrespective of gender, are more obese than their rural counterparts.

In 2012, a multilevel logistic regression study done in Ethiopia, revealed that, age of child, mother's educational level, wealth index, place of residence, had fever in the two weeks before survey, educational level of partner and geographical regions as important factors for child stunting [31].

Multivariate logistic regression study conducted in Combolcha District of Eastern Hararghe, identified household size, child's age, child's immunization status, child's gender, and the mothers use of antenatal care, household farm size, water source, latrine use, and incidence of morbidity as important factors for child malnutrition [87].

### **Mother Education Level**

A study conducted in Ethiopia show a decreased incidence of malnutrition among young children with an increase in the level of mothers' education [34, 109]. A study published in 2004 with regard

to this same topic in Ethiopia found that parental education is one of the key determinants of chronic child malnutrition in Ethiopia [25].

In 2019, a multivariate logistic regression study done in Ethiopia shows that child's age, sex, and perceived birth weight, mother's educational status, BMI, and maternal stature, and region, wealth quintile, type of toilet facility, and type of cooking fuel had significant associations with stunting. Child's age, sex, and perceived birth weight, mother's BMI, and residence and region showed significant associations with wasting among of children under age 5 [10]. This study also shows that as the age of child increases their risk of stunting also increases.

### **Wealth Index of the Household**

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), father's employment and control over income, mother's 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 [35].

The results of a study conducted among children 6-59 months of age in Dollo Ado district Ethiopia using logistic regression revealed that there was a significant association between access to safe drinking water and child nutritional status especially stunting. This could be attributed to the fact that clean water will prevent the spread of water-borne diseases that can negatively affect the health and nutrition of young children [81].

### **Shocks**

The available empirical evidence to date on the effect of income shocks on child growth suggests pervasive growth retardation [43,58]. As such temporary income shocks may cause permanent damage to children's future welfare and cognitive abilities [110]. Using three nationally

representative surveys conducted during 1995-96, [110] find that income shocks, measured by crop damage, reduce child growth substantially, especially among children aged 6 to 24 months. Children in this age group may lose 1 cm growth over a six-month interval when half of their crop area is damaged [110].

### **Dynamics of Child Malnutrition**

A study done in Ethiopia by [13] revealed that children stunted in the beginning of their life has a higher probability to grow up into stunted adults while children not stunted early in life have a higher possibility to grow into not stunted adults. The empirical literature discussion is summarized as follows

Table 2.1: Empirical Review Summary

References	Study place	Results of the study
Ayalew Astatkie ,2020	Ethiopia	Children stunted early in life have a higher probability to grow into stunted adults and vice versa
Amare et.al., 2019	Ethiopia	Child's age, sex, and perceived birth weight, mother's educational status, BMI, and maternal stature, region, wealth quintile, type of toilet facility, and type of cooking fuel had significant correlation with stunting. Child's age, sex, and perceived birth weight, mother's BMI, and residence and region were significantly associations with wasting.
Fekade and Mekonnen, 2012	Ethiopia	Place of residence and mothers education determines under five stunting status.
Genebo and Girma, 2002	Ethiopia	Household economic status, education of parents, no. of prenatal care visits of the mother, child's age, birth order and preceding birth interval are important determinants of child stunting.
Genebo et al., 1999	Gurage zone Ethiopia	mothers' education significantly associated with child nutritional status
Harold and Christiansen, 2004	Ethiopia	mothers' education significantly associated with child nutritional status
Salah E.O. Mahgoub et al., 2006	Botswana	prevalent stunting, wasting and underweight were higher among boys than among girls
Solomon D. and Amare W, 2013	Dolo Ado , Somali Region Ethiopia	Gender and age of child, marital status, maternal education, monthly HH income, decision making, having of livestock, total number of children ever born, health status during pregnancy, pre-lactation practice, mode of feeding, access to clean water and type of floor in the households.
Tadiwos and Degnet, 2013	Eastern Hararghe Zone, Ethiopia	identified household size, child's age, child's immunization status, child's gender, and the mothers use of antenatal care, household farm size, water source, latrine use, and incidence of morbidity as important factors for child malnutrition
Yimer, 2000	Southern Ethiopia	Household economic status, women's education, Age, preceding birth interval were significant factor for malnutrition.

Source: (Empirical Reviewed Summary, 2021)

## CHAPTER THREE

### DATA AND METHODOLOGY

#### 3.1 Source of Data

The source of data for the study comes from Young Lives, a 15-year survey examining the varying nature of childhood poverty in four low and middle income countries specifically Ethiopia, India, Peru and Vietnam [108].

The present study employed the constructed Young Lives dataset for Ethiopia in which the same children are followed over the course of the study. The longitudinal study consist of two cohorts of children namely a younger cohort of 1999 children and an older cohort of 1000 children. For this study we used the younger cohort data in which 1999 children were followed for about 15 years in five rounds. Round 1, Round 2, Round 3 Round 4 and Round 5 were conducted in 2002, 2006, 2009, 2013 and 2016 respectively and measurements were taken when the child average age was 1, 5, 8, 12 and 15 years old.

#### 3.2 Sample Design

The sampling was accomplished using a multistage sampling method at the start of the study in 2002. In the first stage, out of the nine administrative regions and two city administrations in Ethiopia, four regions namely Amhara, Oromia, Southern Nations, Nationalities and Peoples (SNNP), and Tigray and one city administration namely Addis Ababa were selected purposefully to ensure national coverage. These five administrative areas account for about 96% of the nationwide population. In the second stage, three to five woredas were selected per region ensuring representation of different poverty levels, urban and rural areas and food shortage status. Totally 20

woredas were selected. In the third stage of selection, kebeles (lowest administrative units) were selected. At least one kebele was selected from each woreda. A kebele was considered a sentinel site for the panel data collection or was merged with adjacent kebeles to form a sentinel site depending on the number of eligible households in each kebele. Finally, 100 households with a 1-year old child and were selected randomly from each sentinel site. Poor children were purposively over-sampled. A total of 1999 in younger cohort enrolled in the study during first round. Over the five survey rounds i.e. from 2002 to 2016, the attrition rate reached 5.3% for the Younger Cohort. Because of attrition, a total of 1812 children in younger cohort remained in the study in the fifth round [108].

### 3.3 Study Variables

#### 3.3.1 Response Variable

The response variable in this study is child malnutrition status in terms of stunting (Height-for Age - Z score) and thinness (BMI-for-Age). Children whose Height-for-Age Z-score lower than minus two standard deviations (-2SD) and (-3 SD) from the median of the WHO reference population are considered moderately stunted and severely stunted or chronically malnourished respectively. And a child whose BMI-for-Age Z-score below minus two standard deviations (-2SD) and (-3 SD) from the median of the WHO reference population are considered moderately thin and severely thin respectively. Thus the two responses variables are expressed as follows

$$Y_{1i} = \begin{cases} 0, & \text{if not Stunted ( } Z - \text{ score } \geq -2) \\ 1, & \text{if moderatly Stunted ( } -3 \leq Z - \text{ score } < -2) \\ 2, & \text{if severly Stunted ( } Z - \text{ Score } < -3) \end{cases}$$

and

$$Y_{2i} = \begin{cases} 0, & \text{if not Thin ( } Z - \text{ score } \geq -2) \\ 1, & \text{if moderatly Thin ( } -3 \leq Z - \text{ score } < -2) \\ 2, & \text{if severly Thin ( } Z - \text{ Score } < -3) \end{cases}$$

### **3.3.2 Explanatory Variables**

The predictor variables at individual (child) and family (household) levels, expected to be correlated with child nutritional status are: Sex of Child , Region ,Residence , Age of child, Mother's Level of Education, Sex of Household Head, Wealth Index, Household Size , Shock-Death of Livestock in the Household, Shock-Loss of Job/ Source Of Income/ Family Enterprise, Shock-Crop Failure of Household, Shock-Divorce or Separation of Household, Shock-Birth of New Household Member, Shock-Enrolment Of Child In School, Household owned any livestock in the past 12 month, Number of MILK animals in the household , Number of DRAUGHT animals owned by the household and Number of SMALL RUMIANTS animals owned by the household.

## **3.4 Methodology**

In this section both explanatory and inferential statistical data analysis methods used in the study are discussed.

### **3.4.1 Exploratory Data Analysis**

We started with an exploratory data analysis to gain insight into the dataset. Descriptive statistics were used to observe a possible link between explanatory variables and malnutrition. Univariate associations between potential covariates and the response variable were assessed using frequency tables and by fitting each predictor with each response.

### **3.4.2 Statistical Modeling**

Young Lives data are longitudinal and hierarchical in nature, i.e. repeated measurements are taken on the same children through time and children are nested within cluster (sentinel sites). With such data, children within a cluster may be more similar to each other than children belong to other cluster. This rises the questions on the efficiency of models that assume independence of

observations and calls for a statistical model that takes clustered nature of the data into account. And also time itself is often an important independent variable in longitudinal studies. The Generalized mixed effect ordered logistic regression model were fitted to account for correlations at the temporal, individual and cluster levels.

### 3.4.2.1 Marginal GEE Model

In the marginal models settings, the responses are modeled marginalized over all other responses [61]. Generalized estimating equations (GEE) introduced by [51] is an intuitively appealing way to model longitudinal data in marginal models framework. The interest in standard GEE focuses on the relationship between the covariates and the probability of response while response correlation is treated as a nuisance parameter.

When the response categories are ordered, the use of this ordering yield more parsimoniously parameterized models. Further, the resulting odds ratios based on the dichotomized outcome may depend on the cut point chosen to dichotomize the outcome [59]. Models that use cumulative probabilities like proportional odds models, adjacent categories logits and Continuation ratio logits [4,59] are possible choices for modeling ordinal data. Continuation-ratio model is suited when the underlying outcome is irreversible and adjacent-category model designed for situations in which the subject must 'pass through' one category to reach the next category [4] are not used in this analysis. As a result, this paper focused on ordinal logistic regression models under the GEE modeling framework.

Marginal model for ordinal response  $Y_{ij}$  can be generally defined as a partial proportional odds model [68]. A natural extension of this model for longitudinal data is given by:

$$\log \left[ \frac{p(Y_{ij} \leq k | X_{ij}, \tilde{X}_{ij})}{1 - p(Y_{ij} \leq k | X_{ij}, \tilde{X}_{ij})} \right] = \alpha_k + X_{ij}^T \beta + \tilde{X}_{ij}^T \gamma_k, \quad k = 1, 2, 3, \dots, K \quad (1)$$

Model (1) is an extension of the proportional odds model [59,96], in which the effect  $\gamma_{ij}$  varies according to the  $k$  cutoff responses,  $\tilde{\mathbf{X}}_{ij}$  being a subset of  $\mathbf{X}_{ij}$  for which the effect varies.

In the proportional odds model, changes in the  $K - 1$  cumulative logits over time are related to the predictor variables. Although the model includes  $K - 1$  intercepts,  $\alpha_k$  it assumes that the effects of predictor variables are the same across the  $K - 1$  logits, which is equivalent to assuming that the effects of predictor variables on the cumulative odds are proportional [32]. One advantage of the proportional odds model is that regardless of the number of categories, the interpretation of the slope parameter is the same. Another desirable feature is that the slope parameter is interpreted as an odds ratio. Thus, in a study whose response has, for example, 3 ordered categories, we have 2 cumulative logits based on cumulative probabilities of the model (1):

$$\mathbf{logit}_1 = \log \left[ \frac{p(Y_{ij} \leq k | \mathbf{X}_{ij}, \tilde{\mathbf{X}}_{ij})}{1 - p(Y_{ij} \leq k | \mathbf{X}_{ij}, \tilde{\mathbf{X}}_{ij})} \right] = \alpha_1 + \mathbf{X}_{ij}^T \boldsymbol{\beta} + \tilde{\mathbf{X}}_{ij}^T \boldsymbol{\gamma}_1 \quad (2)$$

and

$$\mathbf{logit}_2 = \log \left[ \frac{p(Y_{ij} \leq k | \mathbf{X}_{ij}, \tilde{\mathbf{X}}_{ij})}{1 - p(Y_{ij} \leq k | \mathbf{X}_{ij}, \tilde{\mathbf{X}}_{ij})} \right] = \alpha_2 + \mathbf{X}_{ij}^T \boldsymbol{\beta} + \tilde{\mathbf{X}}_{ij}^T \boldsymbol{\gamma}_2 \quad (3)$$

The  $\mathbf{logit}_1$  and  $\mathbf{logit}_2$ , respectively, represent the log of the odds for the most favorable category compared to other categories, and the log of odds for the 2 most favorable categories compared to the last category.

The cumulative probabilities might be modeled treating the ordinal response as a set of  $K - 1$  variables of the form:

$$\mathbf{U}_{ijk} = \begin{cases} \mathbf{1}, & \text{if } Y_{ij} \leq k \\ \mathbf{0}, & \text{if } Y_{ij} > k \end{cases}$$

A general specification of the marginal model for ordinal responses following

$$\mathbf{logit}(\pi_{ijk}) = \alpha_1 + \mathbf{X}_{ij}^T \boldsymbol{\beta} + \mathbf{Z}_{ij}^T \boldsymbol{\gamma}_1, \text{ in which } \pi_{ijk} = E(\mathbf{U}_{ijk}) = P(Y_{ij} \leq k)$$

$$\text{Var}(\mathbf{U}_{ijk} | \mathbf{X}_{ij}, \mathbf{Z}_{ij}) = \boldsymbol{\pi}_{ijk}(\mathbf{1} - \boldsymbol{\pi}_{ijk})$$

When specifying the intra-individual association, the correlation between the components of  $(\mathbf{U}_{ij1}, \mathbf{U}_{ij2}, \dots, \mathbf{U}_{ij-1k})$  in the  $j^{\text{th}}$  time point is a known function of  $\boldsymbol{\pi}_{ijk}$ .

The components of  $(\mathbf{U}_{ij1}, \mathbf{U}_{ij2}, \dots, \mathbf{U}_{ij-1k})$  in part 3 above are correlated, and this correlation follows from the fact that the probabilities of  $K$  multinomial responses must necessarily add up to 1 for a given point in time [41]. Thus, for instance, the correlation between  $\mathbf{U}_{ij1}$  and  $\mathbf{U}_{ij2}$  can be expressed by:

$$\text{corr}(\mathbf{U}_{ij1}, \mathbf{U}_{ij2}) = \frac{\pi_{ij1} - \pi_{ij1}\pi_{ij2}}{\sqrt{\pi_{ij1}\pi_{ij2}(\mathbf{1} - \pi_{ij1})(\mathbf{1} - \pi_{ij2})}}$$

The estimation of the parameters in the marginal model for ordinal responses is done using the GEE extension proposed by [40]. According to these authors, if the primary interest is to estimate the parameter  $\boldsymbol{\beta}$ , the 1<sup>st</sup> order estimating equations are given by:

$$\mathbf{U}_1^*(\boldsymbol{\beta}, \boldsymbol{\alpha}) = \sum_{i=1}^n \left[ \frac{\partial \boldsymbol{\mu}_i}{\partial \boldsymbol{\beta}_i} \right]^T \mathbf{V}_{i11}^{-1} (\mathbf{U}_i - \boldsymbol{\mu}_i(\boldsymbol{\beta})) \quad \text{and}$$

$$\mathbf{U}_2^*(\boldsymbol{\beta}, \boldsymbol{\alpha}) = \sum_{i=1}^n \left[ \frac{\partial \boldsymbol{\mu}_i}{\partial \boldsymbol{\beta}_i} \right]^T \mathbf{V}_{i22}^{-1} (\mathbf{s}_i - \boldsymbol{\alpha}_i(\boldsymbol{\beta}, \boldsymbol{\alpha}))$$

$\boldsymbol{\mu}_i = \mathbf{g}^{-1}(\text{logit}(\boldsymbol{\pi}_{ij}))$ ;  $\mathbf{V}_{i11} = \mathbf{A}_i^{1/2} \mathbf{R}_i(\boldsymbol{\alpha}) \mathbf{A}_i^{1/2}$ , where  $\mathbf{A}_i$  is a diagonal matrix such that

$\mathbf{A}_i = \text{diag}\{\text{var}(\mathbf{U}_{ijk})\}$ ;  $\mathbf{R}_i(\boldsymbol{\alpha})$  is an  $\mathbf{m}_i \times \mathbf{m}_i$  matrix, known as the working correlation matrix

$\mathbf{U}_i = (\mathbf{U}_{i1}^T, \dots, \mathbf{U}_{im_i}^T)^T$ ; and  $\mathbf{V}_{i22}$  denotes a covariance matrix corresponding to the following

Kronecker product:  $\mathbf{S}_{i(s,j)} = (\mathbf{U}_{is} - \boldsymbol{\mu}_{is}) \otimes (\mathbf{U}_{ij} - \boldsymbol{\mu}_{ij})$  furthermore,  $\boldsymbol{\sigma}_i = \mathbf{E}(\mathbf{S}_i)$ .

Estimation of  $\boldsymbol{\beta}$  and  $\boldsymbol{\alpha}$  in the marginal model for ordinal responses is analogous to the [52] proposition. The difference for ordinal responses is that the covariance

matrix for the vector of responses has a block-diagonal structure, with the covariance determined by  $\boldsymbol{\mu}_i$ .

### 3.4.2.2 Generalized Mixed Effect Ordered Logistic Regression Model

The conditional model (in the sense of a random effect) for cumulative probabilities can be described as in [39], in terms of the following logit:

$$\log \left[ \frac{p(Y_{ij} \leq k | \mathbf{b}_i, \mathbf{X}_{ij}, \tilde{\mathbf{X}}_{ij})}{1 - p(Y_{ij} \leq k | \mathbf{b}_i, \mathbf{X}_{ij}, \tilde{\mathbf{X}}_{ij})} \right] = \boldsymbol{\alpha}_k + \mathbf{X}_{ij}^T \boldsymbol{\beta} + \tilde{\mathbf{X}}_{ij}^T \boldsymbol{\gamma}_k + \mathbf{Z}_{ij}^T \mathbf{b}_i \quad k=1, \dots, K-1 \quad (4)$$

$\mathbf{Z}_{ij}$  is a  $q$ -vector of predictor variables that is a subset of  $\mathbf{X}_{ij}$  usually those ones that change over time, and  $\mathbf{b}_i \sim \mathcal{N}(\mathbf{0}, \mathbf{G})$ . Again, if the effect  $\boldsymbol{\gamma}_k$  in (5) is zero, then the expression reduces to the proportional odds mixed effects.

A general specification for the model of mixed effects in ordinal responses considers:

$$\text{logit}(P(Y_{ij} \leq k | \mathbf{b}_i, \mathbf{X}_{ij}, \tilde{\mathbf{X}}_{ij})) = \boldsymbol{\alpha}_k + \mathbf{X}_{ij}^T \boldsymbol{\beta} + \tilde{\mathbf{X}}_{ij}^T \boldsymbol{\gamma}_k + \mathbf{Z}_{ij}^T \mathbf{b}_i ;$$

Conditional to the vector of random effects  $\mathbf{b}_i$ , the value of  $\mathbf{Y}_{ij}$  are independent and have a multinomial distribution for  $j = 1, 2, \dots, m_i$

The effects  $\mathbf{b}_i$  are assumed to follow a multivariate normal distribution with mean 0 and a  $q \times q$  covariance matrix  $\mathbf{G}$  (for a model with random slopes and intercept).

Thus, the accumulated logit for a response  $\mathbf{Y}_{ij}$  that has, for example, three categories can be expressed as:

$$\log \left[ \frac{p(Y_{ij} \leq 1 | \mathbf{b}_i, \mathbf{X}_{ij}, \tilde{\mathbf{X}}_{ij})}{1 - p(Y_{ij} \leq 1 | \mathbf{b}_i, \mathbf{X}_{ij}, \tilde{\mathbf{X}}_{ij})} \right] = \log \left[ \frac{p(Y_{ij} \leq 1 | \mathbf{b}_i, \mathbf{X}_{ij}, \tilde{\mathbf{X}}_{ij})}{1 - p(Y_{ij} \leq 2 \text{ or } 3 | \mathbf{b}_i, \mathbf{X}_{ij}, \tilde{\mathbf{X}}_{ij})} \right] = \boldsymbol{\alpha}_1 + \mathbf{X}_{ij}^T \boldsymbol{\beta} + \tilde{\mathbf{X}}_{ij}^T \boldsymbol{\gamma}_1 + \mathbf{Z}_{ij}^T \mathbf{b}_i \quad (5)$$

and

$$\log \left[ \frac{p(Y_{ij} \leq 2 | \mathbf{b}_i, \mathbf{X}_{ij}, \tilde{\mathbf{X}}_{ij})}{1 - p(Y_{ij} \leq 2 | \mathbf{b}_i, \mathbf{X}_{ij}, \tilde{\mathbf{X}}_{ij})} \right] = \log \left[ \frac{p(Y_{ij} = 1 \text{ or } 2 | \mathbf{b}_i, \mathbf{X}_{ij}, \tilde{\mathbf{X}}_{ij})}{1 - p(Y_{ij} = 3 | \mathbf{b}_i, \mathbf{X}_{ij}, \tilde{\mathbf{X}}_{ij})} \right] = \boldsymbol{\alpha}_2 + \mathbf{X}_{ij}^T \boldsymbol{\beta} + \tilde{\mathbf{X}}_{ij}^T \boldsymbol{\gamma}_2 + \mathbf{Z}_{ij}^T \mathbf{b}_i \quad (6)$$

Therefore, for an ordinal response containing three categories, the model simultaneously describes the effects of predictor variables under all  $K - 1$  comparisons between the probabilities [39]. The inclusion of random effects in the model has implications for the interpretation of the parameters. Conditional at the random effect, a model as in (4) has the same slope, but different  $\mathbf{b}_i$  for all subjects. Therefore, the interpretation of the regression coefficients in this class of models is done at individual level, and conditional to the random effect

### 3.4.2.3 Markov Transition Model

In longitudinal analysis neither marginal models nor mixed effect models are able to capture directly the progression of the individual's response category from one moment of time to another. To meet this objective, we consider Markov transition model. This model is based on stochastic processes and different processes can be used to define transition models for different situations. For this study, we consider a discrete time discrete state process (with a finite number of states) and a first-order Markov assumption with transition probabilities.

$$\begin{aligned} \pi_{ij}(t - 1, t) &= P(Y_t = j | Y_{(t-1)} = i, Y_{(t-2)} = k, \dots, Y_{(0)} = u) \\ &= P(Y_t = j | Y_{(t-1)} = i) \end{aligned} \quad (7)$$

Where the states  $i, j, k, \dots, u \in S = \{1, 2, \dots, z\}$  is the finite set of discrete states, and time  $t \in \tau = \{0, 1, \dots, T\}$  is the set of observation times. Equation (7) says that an individual's state at time  $t, Y_t$  depends only on the state at the immediately preceding occasion,  $Y_{(t-1)}$  and not the complete history of the process. For any originating state  $i$ , these transition probabilities satisfy the condition  $\sum_{j=0}^z \pi_{ij}(t - 1, t) = 1$  that is at each time the process has to move to one of the  $z$  states that is the system is closed. These models present an interesting approach to explain the process of moving from one response category to another at consecutive times and to assess the behavior of the changes on each time. The set of transition probabilities can be written in matrix form as follows

$$P(t) = \begin{bmatrix} \pi_{11}(t) & \pi_{12}(t) & \pi_{13}(t) & \dots & \pi_{1z}(t) \\ \pi_{21}(t) & \pi_{22}(t) & \pi_{23}(t) & \dots & \pi_{2z}(t) \\ \pi_{31}(t) & \pi_{32}(t) & \pi_{33}(t) & \dots & \pi_{3z}(t) \\ \vdots & \vdots & \vdots & \dots & \vdots \\ \pi_{z1}(t) & \pi_{z2}(t) & \pi_{z3}(t) & \dots & \pi_{zz}(t) \end{bmatrix}, \text{ where } t \text{ shows the dependence on time}$$

For a longitudinal study, as we have here, there are in general T transition matrices with transition probabilities changing over time. These transition terms describe the evolution of the process over time, from one occasion to another. However, a general assumption is that the process is stationary, that is the transition probabilities are homogeneous over time, and the T transition matrices are stochastically equivalent, that is, P (t) is constant over time [48].

### 3.4.3 Working Correlation Structures

In modeling longitudinal data it is important to specify the structure of correlation between the repeated measures of a subject. The most commonly used correlation structures include independence, unstructured, exchangeable (compound symmetry) and autoregressive

**Independence Correlation Structure (IND):** In this correlation structure observations are considered to be independent of one another. The structure assumes a zero correlation between subsequent measures of a subject within time points. This structure is useful if the size of panels is small and if there is evidently no time effect in the data. The scheme of this correlation structure can be shown as follows

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

**Unstructured Correlation Structure (UN):** In the unstructured correlation structure all correlations are assumed to be different; correlations are freely estimated from the data. For our data with 7 time points, its structure is as follows:

$$\begin{bmatrix} 1 & C_1 & C_2 & C_3 & C_4 & C_5 & C_6 \\ C_1 & 1 & C_7 & C_8 & C_9 & C_{10} & C_{11} \\ C_2 & C_7 & 1 & C_{12} & C_{13} & C_{14} & C_{15} \\ C_3 & C_8 & C_{12} & 1 & C_{16} & C_{17} & C_{18} \\ C_4 & C_9 & C_{13} & C_{16} & 1 & C_{19} & C_{20} \\ C_5 & C_{10} & C_{14} & C_{17} & C_{19} & 1 & C_{21} \\ C_6 & C_{11} & C_{15} & C_{18} & C_{20} & C_{21} & 1 \end{bmatrix}$$

**Exchangeable Correlation Structure (Exch):** The exchangeable correlation structure is the most commonly used structure. It is the default for several of the major commercial software implementations. The exchangeable correlation structure assumes that the correlations between measurements within time are the same, irrespective of any time interval. Any correlation value within the structure may be exchanged with any other hence the name exchangeable. The structure is as follows:

$$\begin{bmatrix} 1 & \rho & \rho & \rho & \rho & \rho & \rho \\ \rho & 1 & \rho & \rho & \rho & \rho & \rho \\ \rho & \rho & 1 & \rho & \rho & \rho & \rho \\ \rho & \rho & \rho & 1 & \rho & \rho & \rho \\ \rho & \rho & \rho & \rho & 1 & \rho & \rho \\ \rho & \rho & \rho & \rho & \rho & 1 & \rho \\ \rho & \rho & \rho & \rho & \rho & \rho & 1 \end{bmatrix}$$

**Autoregressive Correlation Structure (AR):** The autoregressive (AR) correlation structure assumes that there is a marked decrease in correlation coefficient values with the corresponding increase in measurements within panel time intervals. Each off-diagonal from the main diagonal decreases by the square of the previous diagonal. For our data with 7 time points, the correlation structure can be expressed as:

$$\begin{bmatrix} 1 & C & C^2 & C^3 & C^4 & C^5 & C^6 \\ C & 1 & C & C^2 & C^3 & C^4 & C^5 \\ C^2 & C & 1 & C & C^2 & C^3 & C^4 \\ C^3 & C^2 & C & 1 & C & C^2 & C^3 \\ C^4 & C^3 & C^2 & C & 1 & C & C^2 \\ C^5 & C^4 & C^3 & C^2 & C & 1 & C \\ C^6 & C^5 & C^4 & C^3 & C^2 & C & 1 \end{bmatrix}$$

### 3.4.4 Model Checking Techniques

After a model is fitted the next important step is checking its model adequacy, assuming that we are primarily satisfied with the final model or model contains variables in their correct functional form. The objective is to look at how closely model fitted responses approximate observed responses. It is based on graphical as well as statistical point of view. There are several steps involved in assessing the appropriateness, adequacy and usefulness of model. First, the overall usefulness was assessed. Second, the importance of each explanatory variable was assessed by carrying out statistical tests of significance of coefficients.

#### 3.4.4.1 Goodness of Fit of the Mode

The goodness of fit or calibration of a model measures how well the model describes the data. Assessing goodness of fit involves investigating how close values predicted by the model are to the observed values. For likelihood based models, statistical tests like Hosmer-lemeshow test, likelihood ratio and graphical method like fitted versus observed plots could be used. But for correlated (clustered) data, GEE method is quasi-likelihood; there were not readily defined analogs to the fit statistics for maximum likelihood estimation and no procedure included any measure of the assessment of fit. However some model criterion measures were provided to asses over all goodness of fit. The QIC measure was particularly useful tool for choosing the best correlation structure. Similarly the QICu measure was used for model selection [38].

## CHAPTER FOUR

### RESULTS AND DISCUSSION

#### 4.1 Descriptive Analysis

In this section, data obtained from 1,734 children who were under younger cohort in Young Lives project is summarized. These children were enrolled to investigate the changing nature of childhood poverty in Ethiopia between 2002 to 2016 G.C. From total of 1,999 children who were enrolled in the study during the first round of the project, 1,734 of them were presented for this study. About 266 (13.2%) observations are missing due to refusal, untraceable, children living abroad during measurement time, child death during the course of survey, extreme measurements and children less than five round measurement. The major covariate of children with their stunting and thinness are presented in Table 4.1 and Table 4.2 respectively.

Table 4.1 shows the summary of malnutrition progressions across covariate according to the stunting status (Height-for Age). At the baseline measurement, 45.2 % and 35.9% of males and females were stunted respectively at the base year. Of children living in urban areas 32.3% were stunted. Region wise the highest proportion of stunting observed in Amhara region (54.0%) while the lowest proportion observed in Addis Ababa city administration (27.5%). From all children whose mothers were uneducated 46.8% of them were stunted while all of children from mothers with higher educational level 18.2% of them were stunted. Furthermore, information on the socio-economic status (wealth index) was important because it provided information about the welfare of the household. In the households with top wealth index, only 24.5% of children were stunted as compared to 48.8% stunted children in lowest wealth index households. About 38%, 40% and 39.3% of stunted children were recorder from the household that owns no milk animal, no drought animal

and no small ruminants' animals respectively. And also 47.7% and 44.3% of children were stunted due to shock that cause death of livestock and crop failure of their household's respectively.

Table 4.1 Summary of Stunting Progress for Categorical Covariates

Explanatory Variable	1 Year			5 year			8 years			12 years			15 years		
	Not stunted (%)	Moderately stunted (%)	Severely stunted (%)	Not stunted (%)	Moderately stunted (%)	Severely stunted (%)	Not stunted (%)	Moderately stunted (%)	Severely stunted (%)	Not stunted (%)	Moderately stunted (%)	Severely stunted (%)	Not stunted (%)	Moderately stunted (%)	Severely stunted (%)
<b>Gender</b>															
Male	54.8%	21.9%	23.3%	68.6%	24.0%	7.4%	78.4%	16.0%	5.6%	73.7%	22.2%	4.1%	62.4%	25.5%	12.0%
Female	64.1%	20.5%	15.4%	70.9%	20.8%	8.3%	81.2%	14.2%	4.6%	69.2%	23.7%	7.1%	88.4%	9.4%	2.2%
<b>Residence</b>															
Urban	67.7%	18.9%	13.5%	77.2%	18.8%	4.0%	87.0%	10.7%	2.3%	80.5%	16.7%	2.9%	83.9%	12.3%	3.8%
Rural	54.7%	22.5%	22.7%	65.7%	24.4%	9.9%	75.8%	17.6%	6.7%	66.5%	26.4%	7.1%	69.3%	21.2%	9.5%
<b>Region</b>															
Tigray	60.0%	23.1%	16.1%	75.0%	19.4%	5.6%	83.4%	14.1%	2.5%	68.3%	26.2%	5.5%	66.9%	25.8%	7.3%
Amhara	46.0%	28.6%	25.4%	68.2%	27.3%	4.5%	77.3%	16.8%	6.0%	61.6%	30.6%	7.8%	68.1%	21.2%	10.7%
Oromiya	55.8%	22.1%	22.1%	58.2%	29.8%	11.9%	80.2%	13.8%	5.9%	74.2%	20.0%	5.8%	75.6%	16.3%	8.1%
SNNP	63.5%	16.5%	20.0%	69.6%	18.4%	12.0%	71.9%	20.0%	8.0%	71.2%	22.5%	6.4%	76.4%	16.5%	7.1%
Addis Ababa	72.8%	15.4%	11.8%	80.5%	16.7%	2.8%	90.5%	7.8%	1.6%	87.6%	12.0%	.4%	91.3%	6.6%	2.1%
<b>Mother's level of education</b>															
None	53.2%	23.7%	23.1%	63.7%	25.7%	10.6%	75.3%	18.3%	6.4%	65.0%	27.5%	7.5%	69.1%	21.4%	9.4%
Adult literacy , Religious or other	44.4%	27.8%	27.8%	66.7%	25.4%	7.9%	75.7%	15.4%	8.9%	65.0%	28.3%	6.8%	68.0%	22.1%	9.9%
Lower Primary (1-4)	67.6%	18.0%	14.5%	73.3%	20.5%	6.2%	81.7%	14.0%	4.3%	72.2%	23.2%	4.6%	76.3%	17.0%	6.7%
Middle Primary (5-8)	66.3%	17.4%	16.3%	75.4%	21.0%	3.7%	87.5%	10.3%	2.2%	83.1%	14.7%	2.2%	82.9%	12.9%	4.3%
High School (9-12)	76.7%	15.5%	7.8%	87.0%	10.9%	2.2%	86.3%	11.5%	2.2%	80.7%	14.5%	4.8%	87.0%	9.6%	3.4%
Higher Education	81.8%	9.1%	9.1%	84.0%	8.0%	8.0%	83.3%	13.9%	2.8%	91.7%	6.3%	2.1%	84.2%	14.0%	1.8%
<b>Wealth tercile</b>															

Bottom	51. 5%	23. 9%	24. 5%	60. 3%	27. 2%	12. 5%	69. 9%	22. 3%	7. 7%	60. 9%	32. 1%	7. 0%	67. 5%	21. 3%	11. .2 %
Middle	62. 3%	21. 9%	15. 8%	68. 9%	23. 7%	7.3 %	77. 1%	16. 7%	6. 2%	65. 4%	27. 6%	7. 1%	68. 1%	22. 1%	9. 8%
Top	75. 5%	14. 5%	10. 0%	81. 5%	15. 6%	2.9 %	88. 7%	8.9 %	2. 4%	80. 6%	15. 7%	3. 7%	81. 3%	14. 0%	4. 8%
<b>Number of MILK animals in</b>															
None	62. 0%	21. 2%	16. 8%	71. 4%	21. 8%	6.8 %	82. 1%	13. 6%	4. 3%	75. 4%	19. 6%	5. 0%	79. 1%	15. 5%	5. 4%
1 to 2	54. 9%	21. 6%	23. 4%	66. 1%	24. 4%	9.5 %	74. 6%	18. 6%	6. 8%	64. 6%	29. 4%	6. 0%	69. 0%	21. 2%	9. 7%
3 to 5	59. 5%	20. 3%	20. 3%	70. 4%	21. 8%	7.7 %	81. 1%	14. 1%	4. 8%	70. 1%	23. 8%	6. 0%	71. 6%	19. 4%	9. 0%
≥ 6	52. 3%	24. 6%	23. 1%	75. 6%	15. 6%	8.9 %	82. 7%	13. 5%	3. 8%	84. 3%	9.8 %	5. 9%	75. 6%	17. 1%	7. 3%
<b>Number of DRAUGHT animals owned by the household</b>															
None	60. 5%	20. 8%	18. 7%	72. 4%	20. 8%	6.8 %	80. 5%	15. 0%	4. 5%	73. 7%	21. 3%	5. 0%	79. 1%	14. 8%	6. 1%
1 to 2	55. 3%	24. 2%	20. 6%	65. 2%	25. 2%	9.6 %	75. 6%	17. 4%	6. 9%	66. 8%	26. 5%	6. 6%	69. 7%	20. 8%	9. 5%
3 to 5	56. 1%	15. 2%	28. 8%	66. 0%	24. 7%	9.3 %	82. 6%	13. 5%	3. 9%	69. 4%	24. 9%	5. 7%	68. 2%	23. 2%	8. 6%
≥ 6	25. 0%	25. 0%	50. 0%	81. 1%	16. 2%	2.7 %	86. 0%	7.0 %	7. 0%	85. 5%	9.1 %	5. 5%	76. 3%	18. 6%	5. 1%
<b>Number of SMALL RUMIANTS animals owned by the household</b>															
Not have	60. 7%	21. 3%	17. 9%	72. 9%	21. 6%	5.4 %	83. 3%	13. 0%	3. 7%	77. 3%	17. 9%	4. 8%	82. 0%	13. 6%	4. 4%
1 to 2	56. 2%	18. 9%	24. 9%	61. 1%	27. 4%	11. 5%	73. 5%	20. 4%	6. 2%	61. 6%	29. 7%	8. 7%	70. 7%	19. 8%	9. 5%
3 to 5	57. 4%	22. 7%	19. 9%	66. 1%	22. 7%	11. 2%	76. 1%	15. 9%	8. 1%	68. 7%	27. 0%	4. 3%	72. 3%	17. 8%	9. 9%
≥ 6	56. 0%	22. 3%	21. 7%	70. 9%	21. 1%	8.0 %	80. 8%	14. 8%	4. 4%	69. 2%	24. 9%	5. 9%	66. 4%	24. 2%	9. 5%
<b>shock-death of livestock</b>															
no	60. 9%	20. 2%	18. 9%	70. 5%	22. 5%	7.0 %	80. 3%	14. 9%	4. 8%	72. 9%	21. 9%	5. 2%	75. 6%	17. 3%	7. 0%
yes	52. 3%	25. 7%	22. 0%	67. 3%	22. 4%	10. 3%	78. 4%	15. 7%	5. 9%	65. 9%	27. 2%	6. 8%	67. 9%	22. 3%	9. 8%
<b>shock-crop failure</b>															
no	61. 5%	20. 6%	18. 0%	72. 0%	21. 5%	6.4 %	80. 8%	14. 3%	4. 9%	74. 4%	20. 9%	4. 7%	74. 7%	18. 3%	7. 0%
yes	55. 7%	22. 3%	21. 9%	60. 9%	26. 1%	13. 0%	76. 6%	17. 6%	5. 9%	59. 1%	31. 6%	9. 3%	74. 5%	16. 3%	9. 2%

Table 4.2 show the summary of malnutrition progressions across covariate according to the thinness status (BMI-for- Age). At the baseline measurement, 17.4 % and 15.5% of males and females were thin respectively. Of children living in urban areas 9.1% were thin. Region wise the highest proportion of thinness observed in SNNP region (21.6%) while the lowest proportion observed in Addis Ababa city administration (7.3%). From all children whose mothers were uneducated 19.6%

of them were stunted while all of children from mothers with higher educational level none of them were thin. Additionally, information on the socio-economic status (wealth index) was important because it provided information about the welfare of the household. In the households with top wealth index, only 8.4% of children were thin as compared to 21.3% thinner children in lowest wealth index households. About 13.5%, 39.5% and 39.3% of thinner children were recorder from the household that owns no milk animal, no drought animal and no small ruminants' animals respectively. And also 39.1% and 38% of children were stunted due to shock that cause death of livestock and crop failure of their household's respectively.

Table 4. 2 Summary of Thinness Progress for Categorical Covariates

Covariate	1 Year			5 year			8 years			12 years			15 years		
	Not Thin (%)	Moderately Thin (%)	Severely Thin (%)	Not Thin (%)	Moderately Thin (%)	Severely Thin (%)	Not Thin (%)	Moderately Thin (%)	Severely Thin (%)	Not Thin (%)	Moderately Thin (%)	Severely Thin (%)	Not Thin (%)	Moderately Thin (%)	Severely Thin (%)
<b>Gender</b>															
male	82.6%	11.4%	6.0%	91.9%	6.1%	2.0%	77.8%	17.8%	4.4%	59.0%	31.6%	9.5%	54.0%	30.0%	15.9%
female	84.5%	11.0%	4.5%	91.2%	6.4%	2.4%	79.6%	17.0%	3.4%	58.6%	30.6%	10.9%	75.7%	17.2%	7.1%
<b>Residence</b>															
urban	90.9%	7.6%	1.5%	91.8%	6.2%	2.0%	80.3%	15.1%	4.6%	64.8%	28.1%	7.1%	74.0%	18.1%	7.9%
rural	79.6%	13.1%	7.3%	91.4%	6.3%	2.3%	77.8%	18.7%	3.6%	55.3%	32.8%	11.9%	58.6%	27.4%	14.0%
<b>Region</b>															
Tigray	86.9%	9.4%	3.6%	88.3%	7.8%	3.9%	70.9%	23.8%	5.3%	52.3%	36.6%	11.0%	59.6%	27.2%	13.2%
Amhara	82.0%	15.1%	2.9%	87.2%	9.9%	2.8%	66.5%	27.0%	6.5%	40.2%	41.0%	18.8%	47.8%	31.3%	20.9%
Oromiya	81.3%	14.2%	4.5%	96.3%	3.1%	0.6%	88.4%	10.2%	1.4%	66.9%	28.3%	4.7%	71.5%	20.9%	7.6%
SNNP	78.4%	9.9%	11.8%	93.9%	4.5%	1.7%	87.3%	10.8%	1.9%	64.5%	27.2%	8.3%	67.4%	22.9%	9.7%

Addis Ababa	92.7%	6.1%	1.2%	91.9%	6.1%	2.0%	78.6%	16.0%	5.3%	72.7%	19.4%	7.9%	78.0%	15.4%	6.6%
<b>Mother's level of education</b>															
None	80.4%	12.9%	6.7%	90.6%	7.1%	2.3%	74.6%	19.9%	5.5%	53.3%	33.7%	13.0%	57.4%	27.7%	14.8%
Adult literacy, Religious or other	88.9%	11.1%	0.0%	93.9%	5.3%	0.9%	81.1%	15.4%	3.6%	59.9%	30.8%	9.3%	60.5%	24.1%	15.4%
Lower Primary (1-4)	85.5%	9.0%	5.5%	93.8%	4.5%	1.7%	80.7%	18.0%	1.2%	60.0%	32.8%	7.2%	67.6%	24.7%	7.7%
Middle Primary (5-8)	88.6%	8.7%	2.7%	92.3%	5.5%	2.2%	82.7%	14.0%	3.3%	64.7%	26.5%	8.8%	72.1%	20.4%	7.5%
High School (8-12)	91.5%	7.8%	0.8%	87.0%	8.7%	4.3%	83.5%	13.7%	2.9%	65.5%	26.9%	7.6%	73.3%	17.1%	9.6%
Higher Education	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	88.9%	5.6%	5.6%	64.6%	27.1%	8.3%	80.7%	12.3%	7.0%
<b>Wealth tercile</b>															
Bottom	78.7%	14.2%	7.1%	90.4%	7.6%	2.0%	75.0%	21.5%	3.5%	51.2%	35.1%	13.7%	44.4%	35.5%	20.1%
Middle	88.3%	8.5%	3.3%	92.3%	4.8%	2.9%	76.7%	18.9%	4.4%	55.0%	33.9%	11.1%	59.4%	26.3%	14.3%
Top	91.6%	6.6%	1.8%	92.2%	6.0%	1.8%	82.9%	13.4%	3.8%	64.6%	27.3%	8.1%	71.8%	20.0%	8.2%
<b>Number of MILK animals in</b>															
None	86.5%	9.5%	4.0%	92.2%	5.6%	2.2%	78.9%	16.6%	4.5%	61.0%	31.0%	8.0%	68.4%	22.2%	9.4%
1 to 2	80.4%	12.2%	7.4%	90.2%	7.5%	2.4%	77.9%	18.2%	3.9%	56.3%	32.1%	11.7%	59.9%	26.4%	13.7%
3 to 5	81.1%	12.5%	6.4%	92.3%	5.6%	2.1%	76.9%	20.1%	3.0%	57.5%	29.9%	12.6%	60.8%	24.4%	14.8%
≥6	78.5%	20.0%	1.5%	93.3%	6.7%	0.0%	94.2%	5.8%	0.0%	54.9%	31.4%	13.7%	56.1%	29.3%	14.6%
<b>Number of DRAUGHT animals owned by the household</b>															
None	60.5%	20.8%	18.7%	72.4%	20.8%	6.8%	80.5%	15.0%	4.5%	73.7%	21.3%	5.0%	79.1%	14.8%	6.1%
1 to 2	55.3%	24.2%	20.6%	65.2%	25.2%	9.6%	75.6%	17.4%	6.9%	66.8%	26.5%	6.6%	69.7%	20.8%	9.5%
3 to 5	56.1%	15.2%	28.8%	66.0%	24.7%	9.3%	82.6%	13.5%	3.9%	69.4%	24.9%	5.7%	68.2%	23.2%	8.6%
≥6	25.0%	25.0%	50.0%	81.1%	16.2%	2.7%	86.0%	7.0%	7.0%	85.5%	9.1%	5.5%	76.3%	18.6%	5.1%
<b>Number of SMALL RUMIANTS animals owned by the household</b>															
Not have	60.7%	21.3%	17.9%	72.9%	21.6%	5.4%	83.3%	13.0%	3.7%	77.3%	17.9%	4.8%	82.0%	13.6%	4.4%
1 to 2	56.2%	18.9%	24.9%	61.1%	27.4%	11.5%	73.5%	20.4%	6.2%	61.6%	29.7%	8.7%	70.7%	19.8%	9.5%
3 to 5	57.4%	22.7%	19.9%	66.1%	22.7%	11.2%	76.1%	15.9%	8.1%	68.7%	27.0%	4.3%	72.3%	17.8%	9.9%
≥6	56.0%	22.3%	21.7%	70.9%	21.1%	8.0%	80.8%	14.8%	4.4%	69.2%	24.9%	5.9%	66.4%	24.2%	9.5%
<b>shock-death of livestock</b>															

no	60.9 %	20. 2%	18. 9%	70.5 %	22. 5%	7.0 %	80. 3%	14. 9%	4.8 %	72. 9%	21. 9%	5.2 %	75. 6%	17. 3%	7.0 %
yes	52.3 %	25. 7%	22. 0%	67.3 %	22. 4%	10. 3%	78. 4%	15. 7%	5.9 %	65. 9%	27. 2%	6.8 %	67. 9%	22. 3%	9.8 %
<b>shock-crop failure</b>															
no	61.5 %	20. 6%	18. 0%	72.0 %	21. 5%	6.4 %	80. 8%	14. 3%	4.9 %	74. 4%	20. 9%	4.7 %	74. 7%	18. 3%	7.0 %
yes	55.7 %	22. 3%	21. 9%	60.9 %	26. 1%	13. 0%	76. 6%	17. 6%	5.9 %	59. 1%	31. 6%	9.3 %	74. 5%	16. 3%	9.2 %

The summary of stunting and thinness at different time points is given in Table 4.3. As can be seen in Table 4.3, the proportion of not stunting increased over time until 8<sup>th</sup> year and decreased at the 12<sup>th</sup> year and starts to increase after 12<sup>th</sup> year. Likewise, the proportion of not thinness increased after baseline year until 5<sup>th</sup> years but starts to decline in a row after 5<sup>th</sup> year.

Table 4.3 Summary of Stunting and Thinness at Different Time Points

Malnutrition Indicators	Follow Up Period of Survey				
	Base year	Round-2	Round-3	Round-4	Round-5
	Av. Age = 1 year	Av. Age = 5 year	Av. Age = 8 year	Av. Age = 12 year	Av. Age = 15 year
<b>Stunting Status</b>					
Not stunted	59.2%	69.7%	79.7%	71.6%	74.7%
Moderately stunted	21.3%	22.5%	15.2%	22.9%	17.9%
Severely stunted	19.6%	7.8%	5.1%	5.5%	7.4%
<b>Thinness Status</b>					
Not Thin	83.5%	91.6%	78.7%	58.8%	64.2%
Moderately thin	11.2%	6.2%	17.4%	31.1%	24.0%
Severely thin	5.3%	2.2%	3.9%	10.1%	11.8%

The plot presented in Figure 1 and Figure 2 displays the longitudinal change of the severity of child malnutrition. From Figure 1 and Figure 2, we note that the overall proportion of children stunted for both severe and moderate statuses seems decreasing with age; however, proportion of thinness seems increasing with age.

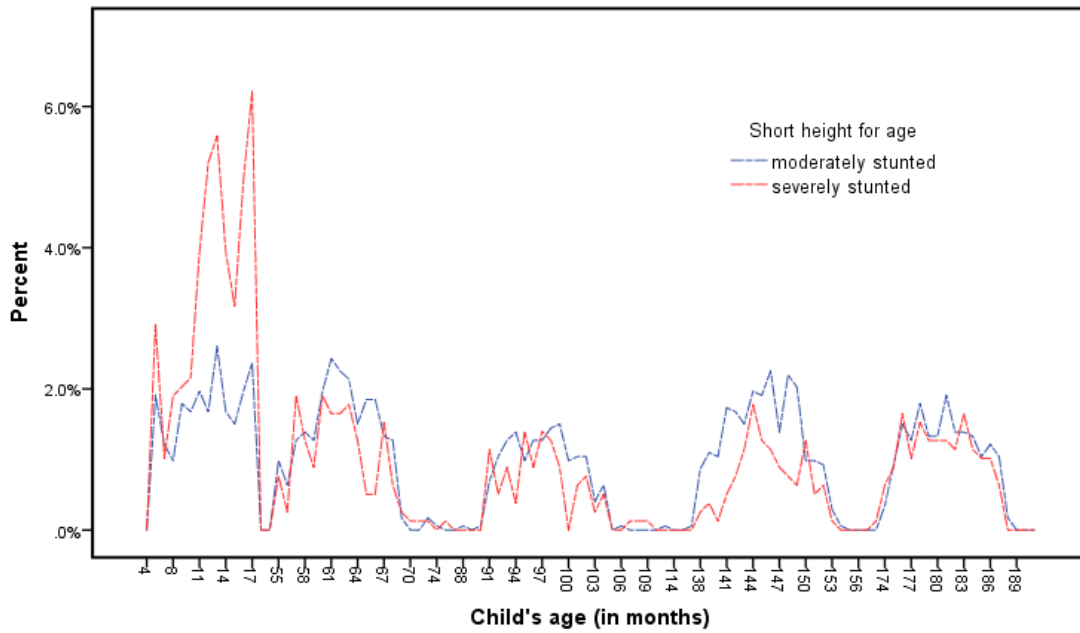


Figure 4.1 Proportion of children stunted by severity stunting with child age in months

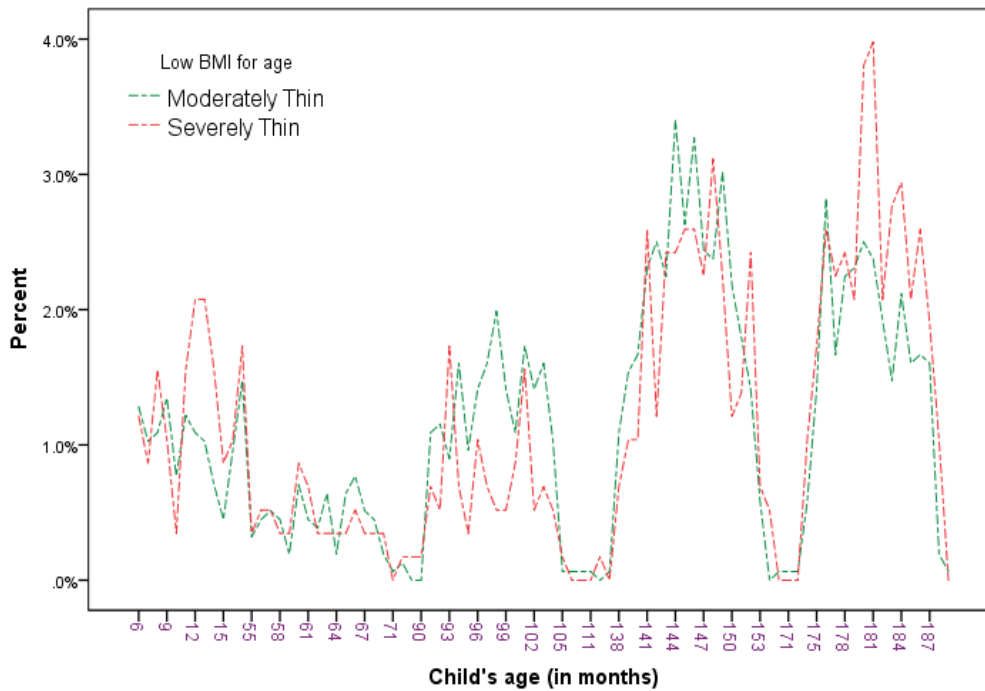


Figure 4.2 Proportion of children thinness by severity thinness with child age in month

## 4.2 Analysis

### 4.2.1 GEE Model Selection Criteria

When the responses are ordinal the usual test of independence ignores the ordering information to test whether there is association between the response and treatment. In a situation, when the likelihood function cannot be fully specified, e.g., as in the GEE case, the Akaike's Information Criterion (AIC) cannot be directly applied for model selection procedures. Instead, one can use the modified Akaike's Information Criterion (QIC) which is based on the quasi-likelihood function [59]. Additionally, QIC is also applicable in selecting a working correlation structure under GEE settings. Firstly, under the GEE, model building strategy started by fitting a model containing all significant covariates in univariate analysis at 20% level of significance. This was done by considering three different working correlation assumptions i.e. exchangeable correlation structure, unstructured correlation structure and autoregressive correlation structure). In order to select the important factors related to child stunting and thinness, the backward selection procedure was used. In this case the procedure was used to remove covariate with non-significant p-values that improve overall fit (i.e. minimize QIC and QICu). The working correlation result the three GEE model is presented in Table 4.4.

Table 4. 4 GEE Model Selection Criteria

Criteria	For Stunting Model			For Thinness Model		
	Working Correlation			Working Correlation		
	Exchangeable	Unstructured	Autoregressive	Exchangeable	Unstructured	Autoregressive
QIC	8597.8	8594	8598.6	8597.6	8598	8598.4
QICu	8576	8576	8576	8576	8576	8576

Depending on the results displayed in Table 4.4, GEE with unstructured working correlation model is found to be the best model to fit stunting data because it has the lowest QIC as compared to GEE with exchangeable working correlation and GEE with Autoregressive working correlation models. On the other hand, GEE with Autoregressive working correlation model is found to be the best model to fit thinness data that the other because it has the lowest QIC result.

#### 4.2.2 Result of Marginal GEE Model

In this section we present the analysis of Marginal GEE Model using SAS version 9.4 result using **PROC GENMOD** procedure. The coefficients in both Table 4.5 and Table 4.6 have a population interpretation rather than an individual one.

Table 4.5 presents Marginal GEE Model analysis of stunting data under unstructured correlation structure. The result suggest that wave of the survey, child's age, child's sex, region, residence, mothers education, the ownership of drought animals are significant determinant factors of stunting. For a given children, keeping the random intercept and other covariates constant, a one month change in time increases the likelihood of being stunted by a multiplicative factor of  $e^{0.0086} = 1.01$ .

Keeping the random intercept and other covariates constant, the likelihood of being stunted for female children was decreased by  $e^{-0.1357} = 0.873$  times that of a male children. As compared to children in Tigray region, the likelihood of being stunted for children in Amhara region and Oromia region was increased by a multiplicative factor of  $e^{0.0995} = 1.10$  and  $e^{0.0881} = 1.09$  respectively . Furthermore, the likelihood of being stunted for children in rural residence was increased by  $e^{-0.0557} = 1.062$  times as compare to their urban counterpart. Holding all other factor constant, an increase in mother's education level from lower primary level to Higher Education level the likelihood of being having the stunted children is decreased by a multiplicative factor from  $e^{-0.0746} = 0.928$  to  $e^{-0.1212} = 0.886$ .

Keeping other covariates constant, children from middle and higher wealth index families the likelihood of being stunted decreased by the multiplicative factor of  $e^{-0.0445} = 0.956$  and  $e^{-0.0791} = 0.924$  respectively. To conclude, children whose household own 6 and above drought animals, their likelihood of being thin was decreased by a multiplicative factor of  $e^{0.0884} = 0.915$  than children from household who own no small ruminants animals.

Table 4. 5 Parameter Estimates of Stunting using Marginal GEE Model

Analysis Of GEE Parameter Estimates with Unstructured Correlation							
Empirical Standard Error Estimates							
Parameter		Estimate	Standard Error	95% Confidence Limits		Z	Pr >  Z
Intercept		0.5470	0.0481	0.4526	0.6414	11.36	<.0001
Wave	2	-0.6302	0.1306	-0.8862	-0.3742	-4.83	<.0001
Wave	3	-1.0555	0.2207	-1.4880	-0.6229	-4.78	<.0001
Wave	4	-1.3732	0.3417	-2.0429	-0.7035	-4.02	<.0001
Wave	5	-1.6894	0.4326	-2.5373	-0.8416	-3.91	<.0001
Sex	2	-0.1357	0.0218	-0.1784	-0.0929	-6.22	<.0001
Age_Months		0.0086	0.0025	0.0037	0.0136	3.41	0.0007
Region	3	0.0995	0.0346	0.0318	0.1673	2.88	0.0040
Region	4	0.0881	0.0354	0.0188	0.1575	2.49	0.0127
Region	7	0.0486	0.0336	-0.0173	0.1145	1.45	0.1482
Region	14	-0.0557	0.0371	-0.1285	0.0171	-1.50	0.1339
Residence	2	0.0603	0.0278	0.0059	0.1147	2.17	0.0299
Mother_Education	1	0.0244	0.0321	-0.0386	0.0873	0.76	0.4484
Mother_Education	2	-0.0746	0.0258	-0.1251	-0.0240	-2.89	0.0038
Mother_Education	3	-0.0861	0.0305	-0.1459	-0.0264	-2.82	0.0047
Mother_Education	4	-0.1329	0.0358	-0.2030	-0.0627	-3.71	0.0002
Mother_Education	5	-0.1212	0.0523	-0.2236	-0.0188	-2.32	0.0204
Wealth_Index	2	-0.0445	0.0183	-0.0804	-0.0086	-2.43	0.0151
Wealth_Index	3	-0.0791	0.0235	-0.1252	-0.0330	-3.36	0.0008
Milk_Animals	1	0.0171	0.0188	-0.0197	0.0538	0.91	0.3627
Milk_Animals	2	-0.0213	0.0221	-0.0645	0.0219	-0.97	0.3342
Milk_Animals	3	-0.0178	0.0403	-0.0968	0.0611	-0.44	0.6582
Drought_Animals	1	-0.0367	0.0197	-0.0754	0.0020	-1.86	0.0631
Drought_Animals	2	-0.0181	0.0255	-0.0681	0.0319	-0.71	0.4770
Drought_Animals	3	-0.0884	0.0441	-0.1749	-0.0019	-2.00	0.0453
Ruminant_Animals	1	0.0221	0.0196	-0.0164	0.0606	1.13	0.2601
Ruminant_Animals	2	-0.0028	0.0186	-0.0393	0.0336	-0.15	0.8788
Ruminant_Animals	3	-0.0066	0.0199	-0.0455	0.0323	-0.33	0.7405
Shock_Death_Livestoc	1	0.0045	0.0149	-0.0246	0.0337	0.30	0.7611
Shock_Crop_Failure	1	0.0124	0.0156	-0.0181	0.0429	0.80	0.4253

Based on the results obtained from the GEE model with AR correlation structure, sex of child, region, wealth index, and number of small ruminant animal own by household were found significant determinant factor for thinness (see Table 4.6). For a given children, keeping the random intercept and other covariates constant, the likelihood of being thin for female children was decreased by  $e^{-0.0826} = 0.923$  times that of a male children. As compared to children in Tigray region, the likelihood of being thin for children in Amhara region was increased by a multiplicative factor of  $e^{0.1046} = 1.110$ . On the other hand, the likelihood of being thin for children in Oromai region was decreased by  $e^{-0.093} = 0.911$  times as compare to their Tigray region counterpart. Keeping other covariates constant, children from middle and higher wealth index families the likelihood of being thin decreased by the multiplicative factor of  $e^{-0.0349} = 0.966$  and  $e^{-0.0726} = 0.923$  respectively. Finally, children whose household own 6 and above small ruminants animal, their likelihood of being thin was increased by a multiplicative factor of  $e^{0.0791} = 1.0823$  than children from household who own no small ruminants animals.

Table 4. 6 Parameter Estimates of Thinness using Marginal GEE Model

Analysis Of GEE Parameter Estimates using AR correlation							
Empirical Standard Error Estimates							
Parameter		Estimate	Standard Error	95% Confidence Limits		Z	Pr >  Z
Intercept		0.2691	0.0398	0.1910	0.3472	6.75	<.0001
Sex	2	-0.0826	0.0170	-0.1159	-0.0493	-4.87	<.0001
Age_Months		0.0005	0.0022	-0.0038	0.0048	0.22	0.8228
Wave	2	-0.1312	0.1105	-0.3478	0.0854	-1.19	0.2352
Wave	3	0.0031	0.1874	-0.3642	0.3703	0.02	0.9870
Wave	4	0.2484	0.2914	-0.3227	0.8195	0.85	0.3939
Wave	5	0.1988	0.3683	-0.5232	0.9207	0.54	0.5894
Region	3	0.1046	0.0300	0.0457	0.1634	3.48	0.0005
Region	4	-0.0930	0.0264	-0.1447	-0.0412	-3.52	0.0004
Region	7	-0.0346	0.0270	-0.0875	0.0183	-1.28	0.2002
Region	14	-0.0390	0.0326	-0.1028	0.0249	-1.20	0.2315
Residence	2	0.0376	0.0257	-0.0128	0.0880	1.46	0.1439
Mother_Education	1	-0.0412	0.0295	-0.0990	0.0166	-1.40	0.1624
Mother_Education	2	-0.0404	0.0222	-0.0839	0.0031	-1.82	0.0685
Mother_Education	3	-0.0399	0.0252	-0.0893	0.0094	-1.59	0.1126
Mother_Education	4	-0.0103	0.0312	-0.0715	0.0509	-0.33	0.7414
Mother_Education	5	-0.0993	0.0524	-0.2020	0.0035	-1.89	0.0583
Wealth_Index	2	-0.0349	0.0168	-0.0677	-0.0020	-2.08	0.0375
Wealth_Index	3	-0.0726	0.0229	-0.1175	-0.0278	-3.17	0.0015
Milk_Animals	1	-0.0117	0.0170	-0.0451	0.0217	-0.69	0.4923
Milk_Animals	2	-0.0222	0.0206	-0.0626	0.0181	-1.08	0.2802

Milk_Animals	3	-0.0402	0.0351	-0.1090	0.0285	-1.15	0.2516
Drought_Animals	1	0.0044	0.0183	-0.0315	0.0404	0.24	0.8089
Drought_Animals	2	-0.0055	0.0231	-0.0508	0.0398	-0.24	0.8132
Drought_Animals	3	0.0820	0.0478	-0.0116	0.1756	1.72	0.0859
Ruminant_Animals	1	0.0238	0.0194	-0.0143	0.0618	1.22	0.2210
Ruminant_Animals	2	0.0220	0.0179	-0.0131	0.0571	1.23	0.2200
Ruminant_Animals	3	0.0791	0.0195	0.0409	0.1173	4.06	<.0001
Shock_Death_Livestoc	1	0.0060	0.0148	-0.0230	0.0350	0.40	0.6862
Shock_Crop_Failure	1	-0.0064	0.0146	-0.0351	0.0223	-0.44	0.6617

### 4.2.3 Results of General Mixed Effect Ordered Logistic Regression Model

In order to quantify the effect of each one of the determinants (by taking into account the ordinal nature of the outcome variable), we considered Equation (4) together with the cluster-level and child-level random effects. The statistical significance of the individual regression coefficients was tested using the Wald chi-square statistic. Accordingly, sex of child, child age in month, mother education level, wealth index and number of drought animal own by household were found significant determinant factors of stunting. On the other hand, Sex of child, child age in month, region, wealth index, number of drought animal own by household and number of small ruminant animal own by household were found significant determinant factor for thinness. Parameter estimates and their standard errors, together with the corresponding adjusted odds-ratios are given in Table 4.7.

#### Risk factor Correlated with Stunting

With a month increase in child age the likelihood of being in the stunted categories (moderate and severe stunted) decreases by 1% (AOR 0.994; 95% CI: 0.996, 0.94). The likelihood of being stunted for female child was 44% (AOR: 0.56; 0.451, 0.690) lower than her male counterpart. It was also observed that odds for child whose mothers were educated at higher education being in severe and moderately category of stunted relative to normal category was decreased by 65% (AOR: 0.35; 0.167, 0.721). Likewise child from mothers with high school education level the odd of being in the

stunted categories lowered by 52% (AOR: 0.48; 0.310, 0.740). And child from mother with lower and middle primary education their likelihood of being in the stunted categories is lowered equally by 38% as compared to child from illiterate mothers. The results in Table 4.5 further revealed that holding all variables constant, the likelihood of being stunted for a child grow up in middle and top wealth categories household was decreased by 38% and 59% respectively than children grow up in low wealth categories household. The fitted model showed that compared to child from household who have no any drought animal, the odds of being stunted decreased by 60% , 34% and 31% among a child form a household who have 6 and above, 3 to 5 and 1 to 2 drought animals respectively.

#### **Risk factor Correlated Thinness (Wasting)**

With a month increase in child age the likelihood of being in the thinness categories (moderate and severe thin) increases by 1.01 (AOR 1.01; 95% CI: 1.13, 1.106) , As compared to a child in Tigray, a child in SNNP 47% less likely to be in moderate or severe thin status. The results in Table 4.7 further revealed that holding all variables constant, the likelihood of being thin for a child from top wealth categories household was decreased by 29% than a child from low wealth categories household. The fitted model showed that compared to child from household who have no any drought animal, the odds of being thin decreased by 20%, among a child form a household who have and 1 to 2 drought animals. However, the odds of being in thinness categories increases by 1.27 (AOR 1.27; 1.062, 1.1706) times for child from the household who have 6 and above small ruminant animal as compare to children from household who have no any small ruminant animal,

Table 4. 7 Odds Ratio Estimates for Correlate of Stunting and Thinness

Category	Covariates	Stunting		Thinness	
		Odd Ratio (95% CI)	p-value	Odd Ratio (95% CI)	p-value
<b>Intercept (threshold)</b>	Intercept-1	0.50(0.009,1.001)	0.054	2.54(2.018,3.067)	0.000
	Intercept-2	2.62(2.11,3.134)	0.000	4.61(4.068,5.146)	0.000
<b>Child Age(in month)</b>	Child Age	0.99(.994,0.996)	0.000	1.01(1.013,1.016)	0.000
<b>Sex</b>	Female	0.56(0.451,0.690)	0.000	0.69(0.574,0.83)	0.000
<b>Region</b>	Amhara	1.60(.993,2.744)	0.088	1.24(0.700,2.215)	0.456
	Oromia	1.58(0.916,2.736)	0.100	0.45(0.251,0.798)	0.006
	SNNP	1.09(0.641,1.841)	0.759	0.53(0.305,0.937)	0.029
	Addis Ababa	0.64(0.336,1.226)	0.180	0.59(0.306,1.129)	0.111
<b>Residence</b>	Rural	1.23(0.849,1.773)	0.277	1.39(0.961,2.001)	0.081
<b>Mother's level of Education</b>	Adult literacy, religion or other	0.84(0.641,1.097)	0.199	0.87(0.668,1.139)	0.315
	Lower Primary	0.62(0.483,.079)	0.000	0.89(0.710,1.139)	0.379
	middle primary	0.62(0.452,0.857)	0.004	0.94(0.706,1.2620)	0.697
	High School vs	0.48(0.310,0.74)	0.001	1.09(0.743,1.589)	0.669
	Higher Education	0.35(0.167,0.721)	0.005	0.64(0.350,1.168)	0.146
<b>Wealth Index</b>	Middle	0.62(0.532,0.732)	0.000	0.85(0.709,1.017)	0.075
	Top	0.41(0.327,0.52)	0.000	0.71(0.550,0.9120)	0.008
<b>Number of MILK animals in the household</b>	1 to 2	1.10(0.916,1.326)	0.301	0.98(0.804,1.183)	0.802
	3 to 5	0.90(0.772,1.121)	0.345	0.97(0.777,1.214)	0.795
	≥ 6	1.05(0.689,1.604)	0.817	1.11(0.723,1.706)	0.631
<b>Number of DRAUGHT animals owned by the household</b>	1 to 2	0.69(0.571,0.823)	0.000	0.80(0.658,0.972)	0.025
	3 to 5	0.66(0.516,0.839)	0.001	0.79(0.618,1.016)	0.066
	≥ 6 vs	0.37(0.221,0.636)	0.000	1.25(0.786,2.001)	0.341
<b>Number of SMALL RUMIANTS animals owned by the household</b>	1 to 2	0.96(0.79,1.165)	0.676	1.005(0.819,1.183)	0.959
	3 to 5	0.84(0.692,1.011)	0.065	0.971(0.797,1.214)	0.777
	≥ 6 vs	0.84(0.69,1.027)	0.089	1.27(1.062,1.1706)	0.011
<b>Shock-death of livestock</b>	Yes	0.88(0.759,1.030)	0.114	0.97(0.831,1.141)	0.742
<b>Shock - Crop failure</b>	Yes	1.15(0.993,1.334)	0.062	1.14(0.98,1.336)	0.095

### 4.2.3 Results of Markov Transition Model

The Markov transition model result shows that the total 3,664 transitions for 1485 male children and a total of 3,272 transitions for 1033 female children by 3 transitions. Their detail transition probability is discussed as follows.

Male children who had not stunted at their 1<sup>st</sup> birthday had 86.67 % probability of remaining not stunted in each round whereas they had 12.56% and 1.43% probability of transitioning into moderate stunting and severe stunting respectively at their 15 year of age. Likewise, female children who had not stunted at their 1<sup>st</sup> birthday had 89.46 % probability of remaining not stunted in each round whereas they had 8.9% and 1.63% probability of transitioning into moderate stunting and severe stunting respectively when they celebrated their 15 years birthday. On the other hand, male children who had moderate stunting at baseline (at 1 year of age) had 39.56% probability of remaining moderately stunted in each round while they had 44.36% probability of transitioning into no stunting (recovery) and 16.8 % probability of transitioning into severe stunting. Female children who had moderate stunting at baseline (at 1 year of age) had 35.5% probability of remaining moderately stunted in each round while they had 54.36% probability of transitioning into no stunting (recovery) and 9.4 % probability of transitioning into severe stunting. This indicates that female children had the higher probability of recovering from moderately stunting and a lower probability of transit from moderately stunted into severely stunted against their male counterpart. Furthermore, male children who initially (at 1 year of age) had severe stunting had 28.92% probability of remaining in severe stunting in each round while they had 31.89% probability of transitioning into not stunting categories and 39.19 % probability of transitioning into moderate stunting. Similarly, female children who initially (at 1 year of age) had severe stunting had 28.62% probability of remaining in severe stunting in each round while they had 31.03% probability of transitioning into not stunting

categories and 40.19 % probability of transitioning into moderate stunting. This indicates that both genders almost have similar probability of recovering from severely stunted.

Table 4. 8 Transition Probabilities of Stunting Status of Children (1<sup>st</sup> to 15<sup>th</sup> birthday)

Initial Stunting Status ( $Y_{it-1}$ )	Sex	Final Stunting Status ( $Y_{it}$ )				Total
		level	Not stunted	Moderately stunted	Severely stunted	
Male	Not stunted	2,170 (86.01)	371 (12.56)	36 (1.43)	2,523 (100)	
	Moderately stunted	305 (39.56)	342 (44.36)	124 (16.00)	771 (100)	
	Severely stunted	118 (31.89)	145 (39.19)	107 (28.92)	370 (100)	
	Total	2,593 (70.77)	804 (21.94)	267 (7.29)	<b>3,664</b> (100)	
Female	Not stunted	2,088 (89.46)	208 (8.91)	38 (1.63)	2,334 (100)	
	Moderately stunted	355 (54.78)	232 35.8	61 9.14	648 (100)	
	Severely stunted	90 (31.03)	117 40.34	83 (28.62)	290 (100)	
	Total	2,533 (76.25)	557 (17.79)	182 (5.96)	<b>3,272</b> (100)	

Male children who had not thin at baseline (at 1 year of age) had 80.82 % probability of remaining not thin in each round whereas they had 16.51% and 2.66% probability of transitioning into moderate thin and severe thin respectfully across the life course to adolescence (at age 15) . Likewise , female children who had not thin at baseline (at 1 year of age) had 83.87 % probability of remaining not stunted in each round whereas they had 13.44% and 2.66% probability of transitioning into moderate stunting and severe stunting respectfully across the life course to adolescence. On the other hand, male children who had moderate thin at baseline (at 1 year of age) had 43.3% probability of remaining moderately thin in each round while they had 34.64% probability of transitioning into no thin (recovery) and 22.6 % probability of transitioning into severe thin. Female children who had

moderate thin at baseline (at 1 year of age) had 35.59% probability of remaining moderately thin in each round while they had 50.47% probability of transitioning into not thin (recovery) and 13.94 % probability of transitioning into severe stunting. This indicates that female children had still the higher probability of recovering from moderately thin and a lower probability of transit from moderately thin into severely thin against their male counterpart. Furthermore, male children who initially (at 1 year of age) had severe thin had 40.92% probability of remaining in severe thin in each round while they had 36.5% probability of transitioning into not thin categories and 23.5 % probability of transitioning into moderate stunting. Similarly, female children who initially (at 1 year of age) had severe stunting had 29.89% probability of remaining in severe thin in each round while they had 42.53% probability of transitioning into not thin categories and 27.59 % probability of transitioning into moderate stunting. This indicates that female children had higher probability of recovering from severely thin than male children

Table 4. 9 Transition Probabilities of Thinness Status of Children (1<sup>st</sup> to 15<sup>th</sup> birthday)

Initial Thinness Status ( $Y_{it-1}$ )	Sex	Final Thinness Status ( $Y_{it}$ )				Total
		level	Not Thin	Moderately Thin	Severely Thin	
Male	Not Thin		2,305 (80.82)	471 (16.51)	76 (2.66)	2852 (100)
	Moderately Thin		212 (34.64)	265 (43.3)	135 (22.06)	612 (100)
	Severely Thin		73 (36.5)	47 (23.5)	80 (40.0)	200 (100)
	Total		2,590 (70.69)	783 (21.37)	291 (7.49)	3664 (100)
Female	Not Thin		2,153 (83.87)	345 (13.44)	69 (2.69)	2,567 (100)
	Moderately Thin		268 (50.47)	189 35.59	74 13.94	531 (100)
	Severely Thin		74 (42.53)	48 27.59	52 (29.89)	174 (100)
	Total		2,495 (76.25)	582 (17.79)	195 (5.96)	3227 (100)

## CHAPTER FIVE

### DISCUSSION, CONCLUSIONS AND POLICY IMPLICATIONS

In this chapter we discuss the main findings of this study, make a conclusion and recommendations.

#### 5.1 Discussion

With a month increase in child age the likelihood of being in the stunted decreases. This result is consistent with previous findings conducted using Young Lives Panel Data by [13, 26, 56]. Conversely this result is in contrast to several previous study conducted in Ethiopia using cross-sectional designs by [2, 19, 88, 89] and that showed an increased risk of stunting with increase in age. However, the studies by reported [2, 88] were limited to only children below five years and the studies reported by [19, 89] were limited to only child aged 6–14 years.

The risk of stunting is significantly higher for children whose mothers have no education than children whose mothers have primary level, secondary and higher level of education. This finding seemed to be consistent with other studies [63,80]. 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 children's health; they tend to look after their children in a better way [60].

## 5.2 Conclusion

The study identified that sex of child, child age in month , mother education level, wealth index and number of drought animal own by household were found significant risk factor correlated with of stunting. On the other hand, Sex of child, child age in month, region, wealth index, number of drought animal own by household and number of small ruminant animal own by household were significantly correlated with malnutrition. Regarding gender specific progression of malnutrition, female children had higher probability of recovering from both moderately stunting and moderately thin and a lower probability of transit from moderately stunted and moderately thin into severely stunted and severely thin against their male counterpart. Both genders almost have similar probability of recovering from severely stunted. While female children still had the higher probability of recovering from severely thin than their male counterpart.

## 5.3 Policy Implications

The findings of this study have policy implications regarding the risk factors correlated with child malnutrition in Ethiopia. The findings need to be converted into development of adequate interventions that aim to decrease malnutrition from Ethiopian children.

- i. The government or concerned bodies should give special attention to improve mothers formal education
- ii. It is also recommend that improving the economic status of the population at household level
- iii. Additionally, it was observed that the risk of being stunted or thin depends on age, sex. However, it is worth noting that the probability of being stunted or also could also be associated with other factors such ownership of draught and small ruminant animas.

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## Appendix

```

Proc genmod data=TMP1.Malnutrition;
class ID Sex(ref='1')Wave(ref='1') Region(ref='1') Residence(ref='1') Mother_Education(ref='0')
Wealth_Index(ref='1') Milk_Animals(ref='0') Drought_Animals(ref='0') Ruminant_Animals(ref='0')
Shock_Death_Livestockv(ref='0') Shock_Crop_Failure(ref='0')/param= ref order = internal;
Model Stunting= Sex Age_Months Wave Region Residence Mother_Education Wealth_Index Milk_Animals
Drought_Animals Ruminant_Animals Shock_Death_Livestockv Shock_Crop_Failure;
repeated subject = ID / type= Uns corrw;
run;

```

### The GENMOD Procedure

#### Model Information

<b>Data Set</b>	TMP1.MALNUTRITION	Written by SAS
<b>Distribution</b>	Normal	
<b>Link Function</b>	Identity	
<b>Dependent Variable</b>	Stunting	Short height for age

#### GEE Model Information

<b>Correlation Structure</b>	Unstructured
<b>Subject Effect</b>	ID (1734 levels)
<b>Number of Clusters</b>	1734
<b>Clusters With Missing Values</b>	51
<b>Correlation Matrix Dimension</b>	5
<b>Maximum Cluster Size</b>	5
<b>Minimum Cluster Size</b>	0

Algorithm converged.

#### Working Correlation Matrix

	Col1	Col2	Col3	Col4	Col5
<b>Row1</b>	1.0000	0.3719	0.2961	0.3171	0.2892
<b>Row2</b>	0.3719	1.0000	0.5065	0.4980	0.3354
<b>Row3</b>	0.2961	0.5065	1.0000	0.4990	0.3842
<b>Row4</b>	0.3171	0.4980	0.4990	1.0000	0.4746
<b>Row5</b>	0.2892	0.3354	0.3842	0.4746	1.0000

#### GEE Fit Criteria

QIC	8594.6473
QICu	8576.0000

Analysis Of GEE Parameter Estimates

Empirical Standard Error Estimates

Parameter		Estimate	Standard Error	95% Confidence Limits		Z	Pr >  Z
Intercept		0.5470	0.0481	0.4526	0.6414	11.36	<.0001
Sex	2	-0.1357	0.0218	-0.1784	-0.0929	-6.22	<.0001
Age_Months		0.0086	0.0025	0.0037	0.0136	3.41	0.0007
Wave	2	-0.6302	0.1306	-0.8862	-0.3742	-4.83	<.0001
Wave	3	-1.0555	0.2207	-1.4880	-0.6229	-4.78	<.0001
Wave	4	-1.3732	0.3417	-2.0429	-0.7035	-4.02	<.0001
Wave	5	-1.6894	0.4326	-2.5373	-0.8416	-3.91	<.0001
Region	3	0.0995	0.0346	0.0318	0.1673	2.88	0.0040
Region	4	0.0881	0.0354	0.0188	0.1575	2.49	0.0127
Region	7	0.0486	0.0336	-0.0173	0.1145	1.45	0.1482
Region	14	-0.0557	0.0371	-0.1285	0.0171	-1.50	0.1339
Residence	2	0.0603	0.0278	0.0059	0.1147	2.17	0.0299
Mother_Education	1	0.0244	0.0321	-0.0386	0.0873	0.76	0.4484
Mother_Education	2	-0.0746	0.0258	-0.1251	-0.0240	-2.89	0.0038
Mother_Education	3	-0.0861	0.0305	-0.1459	-0.0264	-2.82	0.0047
Mother_Education	4	-0.1329	0.0358	-0.2030	-0.0627	-3.71	0.0002
Mother_Education	5	-0.1212	0.0523	-0.2236	-0.0188	-2.32	0.0204
Wealth_Index	2	-0.0445	0.0183	-0.0804	-0.0086	-2.43	0.0151
Wealth_Index	3	-0.0791	0.0235	-0.1252	-0.0330	-3.36	0.0008
Milk_Animals	1	0.0171	0.0188	-0.0197	0.0538	0.91	0.3627
Milk_Animals	2	-0.0213	0.0221	-0.0645	0.0219	-0.97	0.3342
Milk_Animals	3	-0.0178	0.0403	-0.0968	0.0611	-0.44	0.6582
Drought_Animals	1	-0.0367	0.0197	-0.0754	0.0020	-1.86	0.0631
Drought_Animals	2	-0.0181	0.0255	-0.0681	0.0319	-0.71	0.4770
Drought_Animals	3	-0.0884	0.0441	-0.1749	-0.0019	-2.00	0.0453
Ruminant_Animals	1	0.0221	0.0196	-0.0164	0.0606	1.13	0.2601
Ruminant_Animals	2	-0.0028	0.0186	-0.0393	0.0336	-0.15	0.8788
Ruminant_Animals	3	-0.0066	0.0199	-0.0455	0.0323	-0.33	0.7405
Shock_Death_Livestoc	1	0.0045	0.0149	-0.0246	0.0337	0.30	0.7611
Shock_Crop_Failure	1	0.0124	0.0156	-0.0181	0.0429	0.80	0.4253

Proc genmod data=TMP1.Malnutrition;

```

class ID Sex(ref='1')Wave(ref='1') Region(ref='1') Residence(ref='1')
Mother_Education(ref='0') Wealth_Index(ref='1') Milk_Animals(ref='0')
Drought_Animals(ref='0') Ruminant_Animals(ref='0') Shock_Death_Livestockv(ref='0')
Shock_Crop_Failure(ref='0')/param= ref order = internal;
Model Thinness = Sex Age_Months Wave Region Residence Mother_Education Wealth_Index
Milk_Animals Drought_Animals Ruminant_Animals Shock_Death_Livestockv Shock_Crop_Failure;
repeated subject = ID / type= AR corrw;
run;

```

The SAS System

The GENMOD Procedure

Model Information

Data Set	TMP1.MALNUTRITION	Written by SAS
Distribution	Normal	
Link Function	Identity	
Dependent Variable	Thinness	Low BMI for age

Algorithm converged.

GEE Model Information

Correlation Structure	AR(1)
Subject Effect	ID (1734 levels)
Number of Clusters	1734
Clusters With Missing Values	51
Correlation Matrix Dimension	5
Maximum Cluster Size	5
Minimum Cluster Size	0

Algorithm converged.

Working Correlation Matrix

	Col1	Col2	Col3	Col4	Col5
Row1	1.0000	0.3629	0.1317	0.0478	0.0173
Row2	0.3629	1.0000	0.3629	0.1317	0.0478
Row3	0.1317	0.3629	1.0000	0.3629	0.1317
Row4	0.0478	0.1317	0.3629	1.0000	0.3629
Row5	0.0173	0.0478	0.1317	0.3629	1.0000

GEE Fit Criteria

QIC	8592.8544
QICu	8576.0000

Analysis Of GEE Parameter Estimates

Empirical Standard Error Estimates

Parameter		Estimate	Standard Error	95% Confidence Limits		Z	Pr >  Z
Intercept		0.2691	0.0398	0.1910	0.3472	6.75	<.0001
Sex	2	-0.0826	0.0170	-0.1159	-0.0493	-4.87	<.0001
Age_Months		0.0005	0.0022	-0.0038	0.0048	0.22	0.8228
Wave	2	-0.1312	0.1105	-0.3478	0.0854	-1.19	0.2352
Wave	3	0.0031	0.1874	-0.3642	0.3703	0.02	0.9870
Wave	4	0.2484	0.2914	-0.3227	0.8195	0.85	0.3939
Wave	5	0.1988	0.3683	-0.5232	0.9207	0.54	0.5894
Region	3	0.1046	0.0300	0.0457	0.1634	3.48	0.0005
Region	4	-0.0930	0.0264	-0.1447	-0.0412	-3.52	0.0004
Region	7	-0.0346	0.0270	-0.0875	0.0183	-1.28	0.2002
Region	14	-0.0390	0.0326	-0.1028	0.0249	-1.20	0.2315
Residence	2	0.0376	0.0257	-0.0128	0.0880	1.46	0.1439
Mother_Education	1	-0.0412	0.0295	-0.0990	0.0166	-1.40	0.1624
Mother_Education	2	-0.0404	0.0222	-0.0839	0.0031	-1.82	0.0685
Mother_Education	3	-0.0399	0.0252	-0.0893	0.0094	-1.59	0.1126
Mother_Education	4	-0.0103	0.0312	-0.0715	0.0509	-0.33	0.7414
Mother_Education	5	-0.0993	0.0524	-0.2020	0.0035	-1.89	0.0583
Wealth_Index	2	-0.0349	0.0168	-0.0677	-0.0020	-2.08	0.0375
Wealth_Index	3	-0.0726	0.0229	-0.1175	-0.0278	-3.17	0.0015
Milk_Animals	1	-0.0117	0.0170	-0.0451	0.0217	-0.69	0.4923
Milk_Animals	2	-0.0222	0.0206	-0.0626	0.0181	-1.08	0.2802
Milk_Animals	3	-0.0402	0.0351	-0.1090	0.0285	-1.15	0.2516
Drought_Animals	1	0.0044	0.0183	-0.0315	0.0404	0.24	0.8089
Drought_Animals	2	-0.0055	0.0231	-0.0508	0.0398	-0.24	0.8132
Drought_Animals	3	0.0820	0.0478	-0.0116	0.1756	1.72	0.0859
Ruminant_Animals	1	0.0238	0.0194	-0.0143	0.0618	1.22	0.2210
Ruminant_Animals	2	0.0220	0.0179	-0.0131	0.0571	1.23	0.2200
Ruminant_Animals	3	0.0791	0.0195	0.0409	0.1173	4.06	<.0001
Shock_Death_Livestoc	1	0.0060	0.0148	-0.0230	0.0350	0.40	0.6862
Shock_Crop_Failure	1	-0.0064	0.0146	-0.0351	0.0223	-0.44	0.6617



