



Addis Ababa University  
Office of Graduate Program  
Faculty of Science  
Department of Statistics

Determinants of Nutritional Status of Children in Ethiopia  
Using Multilevel Analysis

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## ABSTRACT

This study attempts to identify the determinants of nutritional status of children in Ethiopia. The study focuses on children aged less than 59 months based on data from 2005 Ethiopia Demographic and Health Survey. A total of 3095 children were included in this study. As the outcome measure of nutritional status, stunting (an anthropometric index of height for age) defined as a binary outcome is taken as the dependent variable. A preliminary univariate analysis was used to see the percentage share of background variables with respect to the nutritional status of children. In order to examine the different factors of nutritional status, multiple logistic regressions were employed. Moreover, a multilevel logistic regression analysis is considered to identify the determinants of stunting in children within regions as well as between regions. The multivariate results using three logistic regressions for urban, rural and national level samples revealed that the most important socioeconomic, demographic, health and environmental factors related to nutritional status of children are individual, parental, household and regional factors. The results indicated that nutritional status varies across regions and urban and rural divisions. Furthermore, the results indicated that household economic status, mother's employment status, age of child, preceding birth interval and source of drinking water are some of the factors that affect nutritional status of children directly or indirectly.

# CHAPTER ONE

## INTRODUCTION

### 1.1 Background

Nutrition and health are important dimensions of human well-being. Malnutrition and sickness represent the main health problems in developing countries. Malnutrition among women is likely to have a major impact on their own health and their children. Besides her own health, a mother's nutritional status affects her capacity to successfully care for her children (Abey, 1995). Women in the reproductive age group and children are most vulnerable to malnutrition due to low dietary intakes, inequitable distribution of food within the household, improper food storage and preparation, dietary taboos and infectious diseases (EDHS, 2006). Particularly for women the high nutritional costs of pregnancy and lactation also contribute significantly to their poor nutritional status (Woldemariam and Timotiws, 2002).

The nutritional status of infants and children under five years of age is of particular concern since the early years of life are crucial for optimal growth and development. Their nutritional well-being reflects household, community and national investments in family health thereby contributing both directly and indirectly to overall country development and in particular, development of human resource. It is reliably estimated that globally 226 million children below 5 years old are stunted, 67 million are wasted and 183 million weigh less than they should for their age (Woldemariam and Timotiws, 2002).

The prevalence of stunting in children below five years in East Africa averages about 48 percent (ACC/SCN, 2000), which is the highest in the world. Evidence also showed that the situation in Ethiopia is worse than in other East African Countries. A review of the trends of the nutritional status of Ethiopian children from 1993-1998 showed that the national rural prevalence of stunting increases from 60 percent in 1983 to 64 percent in 1992. Another national survey undertaken in 1998 with the inclusion of urban areas and children in the age group 3-5 months showed a relative decline in the proportion of stunted children to 52 percent (Zewditu et al., 2001). A study conducted by Yimer

(2000) on child nutrition have also shown similar results (a more than 40 percent prevalence in stunting) and confirmed that malnutrition, i.e., stunting, is one of the most important public health problems in this country.

Since children are the economic assets to the world and their future development outcome can be influenced by their nutritional status, the mechanism and consequences of malnutrition need to be understood better. This is true in a country like Ethiopia where malnutrition is almost common. Therefore, there is a need to assess the factors correlated with nutritional status of children so that interventions can be planned to children achieve optimum growth and development.

Malnutrition is the outcome of inadequate dietary intake both in terms quality and quantity of foods, and infectious diseases. These two essential factors are the ultimate outcomes of many other underlying causes. A variety of factors starting from the national level down to the individual interplay in the causation of malnutrition (UNICEF, 1990). Factors that are contributing to malnutrition may differ across regions, communities and overtime. Identifying the underlying causes of malnutrition in a particular locality is important to solve the nutritional problems.

All national surveys on child nutrition analysis were mainly descriptive in nature and limited to the study of associations between nutritional statuses with certain nutrition-related variables. Few studies have been done on risk factors of malnutrition in children using multivariate methods such as logistic regression, and most of these studies are based on small-scale survey data concentrated on certain regions. The present study is based on the Ethiopian 2005 Demographic and Health Survey (DHS) data with reference to children less than 59 months using multiple logistic and multilevel logistic regression analysis.

## **1.2 Statement of the problem**

Many demographers and scholars do believe and recommend the need to conduct in-depth studies on the various aspects of children's nutritional status in different demographic, economic and socio-cultural settings. The researcher shares the idea and the main reason behind the need to study on the socio-economic, demographic, health

and environmental determinants and differentials of nutritional status in Ethiopia is, so far, there are no much detailed studies conducted to explore all aspects of nutritional status in Ethiopia particularly on the effects of socio-economic factors to wards malnutrition.

This study try to explore the major socio-economic, demographic, health and environmental factors that affect nutritional status in Ethiopia like education of the partner, economic status of the household, mothers' education, etc.

### **1.3 Objective of the study**

#### **General Objective:**

The general objective of this study is to examine the level and the various possible factors and their contribution for the current high prevalence of malnutrition using the most recent data in Ethiopia. Further the study examines regional differences in nutritional status using multilevel analysis.

#### **Specific Objectives:**

1. To identify socioeconomic and demographic determinant of child nutritional status among those included in the survey DHS for rural, urban and national level as a whole.
2. To select most important variables that related to nutritional status of children based on DHS.
3. To examine within and between regional level differences in determining the nutritional status of children.

### **1.4 Significance of the study**

The findings obtained from this research hoped to be useful in many ways. Since the study reveals the major responsible factors and their relative contribution for the malnutrition of children under five years of age in the areas, the end user governmental and non-governmental organizations could take intervention measures and set

appropriate plans to tackle and improve the existing health and nutrition problems by identifying and giving priority for the very poor and vulnerable groups.

The findings are also believed to be helpful for policy making, monitoring and evaluation the activities of the government and different concerned agencies. This study is likely to contribute its part by filling the information gap concerning health and nutrition for the country. Finally, the study could be used as a stepping stone for further studies.

### **1.5 Limitations of the study**

Although many factors affect chronic malnutrition as indicated by different studies in different countries including the different social, economic, political, cultural, demographic, physiological, biological, reproductive health rights, family planning policies/programs etc., the study has already undertaken to explore a few of the socio-economic, demographic, health and environmental determinants and differentials of nutritional status in Ethiopia. In the process of calculating the Z-scores (height for age), checks are made on their plausibility. In this study missing and flagged values are omitted from the data set because Z-scores which are sensitive to changes can be assigned incomplete data of birth like month or year missing or don't know. In the analysis of data using multilevel logistic regression a student version of LISREL software is used which is restricted to handle few explanatory variables.

### **1.6 Definition of terms**

1. **Malnutrition**:- the level of nutritional status of children expressed by anthropometric indicators (weight and height) which may result from protein energy malnutrition (Berg, 1981).
2. **Height-for age (H/A)**:- reflects cumulative linear growth, extreme case of low H/A (Z-score below -2SD) is referred to as “stunting”.
3. **Protein Energy Malnutrition**: - under-nutrition that results in an individual not receiving adequate protein or calories for normal growth, body maintenance and the energy necessary for ordinary human activities (Jelliffe, 1982).

4. **Birth interval:** - the length of time between two successive births indicates the pace of childbearing.

### **1.5 Organization of the study**

This study contains five major chapters. Chapter one presents background of the study, objectives, statement of the problem, its significance and limitation of the study. Chapter two deals with review of related literature on nutritional status of children either in or outside Ethiopia. Chapter three discusses the data and methodology of the study such as sources of data and variables to be included in the study with their coding and description. Methods of data analysis are also described in this chapter. Chapter four presents statistical data analysis and discussion. Finally, summary of the main findings, conclusions and policy recommendations of the study are dealt in chapter five.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Anthropometric assessments

Anthropometric measure is the commonly used direct methods for the assessment of nutritional status. The frequently employed anthropometric measurements are weight and height. Anthropometric measurements are economical to carry out, objective, easily understandable, give result which can be numerically graded and provides information on different degree of malnutrition (Dibley et al., 1987). Therefore, most studies on nutritional status are performed using anthropometric measurements.

Since children's height and weight changes with age, the anthropometric measurements were converted into Z-scores based on National Center for Health Statistics (NCHS) growth standard. The NCHS standard is based on a reference population made up of children who are assumed to be well nourished and is recommended by WHO as a reference to be used in the evaluation of nutritional status (Dibley et al., 1987; Woldemariam and Timotiows, 2002; Yimer, 2000; Micheal, 2000 ).

#### 2.2 Factors Associated with Children's Malnutrition

Inadequate dietary intake and diseases play a decisive role in the causation of malnutrition. These two essential factors are only the ultimate outcomes of many other underlying causes. A verity of factors starting from the national level down to the individual interplay in the causation of malnutrition (UNICEF, 1990). Factors that are contributing to malnutrition may differ among regions, communities and over time. Identifying the underlying causes of malnutrition in a particular locality is important to solve the nutritional problems.

Various studies have been made and conclusions were reached by different scholars in the past regarding predictors of health and nutritional status. Survey of available literature indicated that factors like knowledge of health practices and caring level,

educational level of parents, access to or interactions of age of the child have strong effect on household and community variables in which the child grows up.

The detailed literature review presented next focuses on the socioeconomic, demographic, and health and environmental determinants of malnutrition in children.

### **2.2.1 Socioeconomic Characteristics**

Education of women is believed to exert an impact on health and nutritional status of children since it provides the mother with the necessary skills for child care, increase awareness of nutritional needs and preference of modern health facilities as well as change of traditional beliefs about diseases causation, and use of contraceptives for birth spacing (UN, 1985). Studies in Bangladesh (Chaudhury, 1988), Kenya (Kogi-Makua, 1996), Tanzania (Maurie, 1992), and Ethiopia (Aschalew, 2000; Micheal, 2000; Gugsu, 1998) indicate the relationship between chronic nutritional status of children and maternal education.

Education is one of the most important resources that enable women to provide appropriate care for their children, which is an important determinant of children's growth and development (Engle et al., 1996). Studies in the Libya (Popkin, 1980), and Ethiopia (Yimer, 2000; Genebo et al., 1999) showed a decrease in the incidence of malnutrition among young children with an increase in the level of mothers' education. Strauss (1990) suggested that educational level of parents (both mother and father) have significant positive effect on height for age and weight for height.

Household economic status is one of the most important determinants of nutritional status of children. Comparative studies on child nutrition for more than 15 countries (Sommerfelt et al., 1994) and some local studies in Ethiopia (Genabo et al., 1999) showed that the higher the level of economic status of the household, the lower the level of child stunting. The study shows that, as compared with children residing in medium or higher economic status households, the risk of being undernourished for children in very poor or poor households were significant. This finding is consistent with other studies and the UNICEF conceptual frame work (UNICEF, 1990). The conceptual framework indicates that household economic status is positively associated with

household food security, which is a pre-requisite for access to adequate dietary intake and improved nutritional status for all members of the household.

Household income serve as an indicator of children consumption of goods and services that affect their health including among others calories and nutrients, clothing and shelter, sanitary facilities, use of medical system and adult supervision. Increasing individual income and purchasing power is, therefore, regarded as an important prerequisite for improved nutritional status of the community and with the improvement of household income; absolute expenditure on food is likely to go up, as it the calorie and protein intake of the household (UN, 1985).

Although women's employment enhances the household's accessibility to income, it may also have negative effects on the nutritional status of children, as it reduces a mother's time for childcare. Some studies have revealed that mothers of the most malnourished children work outside their home (Popkin, 1980; Abbi et al., 1991). Another study argued that there is no association between maternal employment and children's nutritional status (Leslie, 1988).

Urban-rural differentials of a population is also important because it determines, in most cases, the availability of food, health services and the cultural set up of an area in terms of the type of food preferred and consumed by a certain group of people. For instance, a study by UN (1985) found that environmental conditions (the availability of safe water, sanitation and electricity) affect the health and nutritional status of children. As argued by the UN, the pattern of variation in the less developed countries appeared to be different from that of the developed region. In developing nations, regional differences in child's nutritional status are not entirely explained by socio-economic inequalities alone. Summerfelt and Stewart (1994) found that there was a significant difference in the prevalence of chronic malnutrition between rural and urban children.

Woldemariam and Timotiows (2002) performed comparative study for urban, rural and combined urban and rural children. They identified region of residence, education of mother, economic status of the household and age of the child as determinants of stunting among urban children. For rural children, the analyses showed that region of

residence, education of mother, education of partner, age, birth order and preceding birth interval of the child as important predictors of nutrition status. The combined urban and rural (national) sample results indicated that region of residence, education of mother, education of father, economic status of the household, age, birth order and birth interval of the child were found to be determinants of child nutritional status.

### **2.2.2 Demographic Characteristics**

Household demographic factors such as age and sex of the child are important correlates of nutritional status. Children's nutritional status is more sensitive for some factors at specific age, for example, during the first 4 or 6 months feeding practices and mother's ability to care for the child are the main determinants of child growth. After the age at which the child starts supplementary feeding (from age 4 to 6 months) through 2 years of age the major influences are weaning practices and exposure to infectious diseases. After 2 years of age household food securities have major effect (UN, 1985). Zlotkin (1991) found that height-for-age is highly correlated with age of the child. Cumulative indicators of growth retardation, such as height-for-age, weight-for-age, are positively related to age, with the lower values achieved by certain age (Pelletier, 1991).

The influence of the sex of a child on nutritional status has been the subject of numerous and often contradictory hypothesis or results. The prevalence of malnutrition is higher among female children than among male children because of the preferential treatment of male children or advantages to male infants by way of paternal care, feeding pattern, food distribution within the family and treatment of illness (Abey, 1995). On the contrary, most studies based on anthropometric data showed that the proportion of stunted male children was slightly higher than females.

In combination with other factors, high birth order and low birth intervals are reported to have their share in poor childhood health and nutrition outcomes. Comparative studies done by Sommerfelt et al., (1994) showed that stunting is rare in birth order 2-3, and higher birth order (5+) is positively associated with child malnutrition. The negative effect of birth order four and above is also confirmed in the study done in Ethiopia (Melaku, 1997; Aschalew, 2000; EDHS, 2001 and 2006). The positive significant

relationship between childbirth order and prevalence of stunting could be explained by the fact that the family pot is shared among a large number of people in the household, thus inadequate dietary intake by children for a prolonged period and eventually the manifestation of chronic malnutrition.

Birth intervals are among many important factors affecting nutritional status of children. A short birth intervals means a mother becomes pregnant in short period of time and will give birth to many children that she cannot feed properly because she may have more children to care for. Higher birth spacing is likely to improve child nutrition, since the mother gets enough time for proper childcare and feeding. This implies that longer intervals between births are the means of preventing children from malnutrition. Studies in developing countries showed that children born after a short birth interval (less than 24 months) have higher level of stunting in most countries where DHS surveys have been conducted (Sommerfelt et al., 1994).

### **2.2.3 Health and Environmental Characteristics**

Recent illnesses significantly contribute in precipitating malnutrition in marginally nourished children. Diarrhea exerts this influence by depleting the body of fluids. The traditional practice of withholding food from the child suffering from diarrhea diseases also plays an important role. Fever accelerates the onset of malnutrition by reducing food intake and increasing catabolic reactions in the organism (WHO, 1986). Studies in New-Guinea (Han-Am and Sleigh-A, 1995) and Ethiopia (Aschalew, 2000; Gugsu, 1998) revealed that the nutritional status of children based on height-for-age is associated with the presence of recent symptom of illness, fever and diarrhea.

Diarrhea and other infectious diseases manifested in the form of fever affect both dietary intake and utilization, which may have a negative effect on improved child nutritional status. A study on children's nutritional status (Sommerfelt et. al., 1994) indicated that stunting was highest among children with recent diarrhea.

In the above literature reviews statistical methods such as descriptive and logistic regression on different factors that affect the nutritional status have been used. The present study is based on a recent national data from the 2005 Demographic and Health

Survey with reference to children less than 59 months using multiple and multilevel logistic regression analysis.

## CHAPTER THREE

### MATERIALS AND METHODOLOGY

#### 3.1 Source of Data

The data in this study is based on 2005 Demographic and Health Survey which is obtained from the Central Statistical Agency (CSA), Ethiopia. The 2005 Ethiopian Demographic and Health Survey (EDHS) is the second comprehensive survey designed to provide estimates for the health and demographic variables of interest for the following domains: Ethiopia as a whole; urban and rural areas of Ethiopia (each as a separate domain); and 11 geographic areas (9 regions and 2 city administrations), namely: Tigray; Affar; Amhara; Oromiya; Somali; Benishangul-Gumuz; Southern Nations, Nationalities and Peoples (SNNP); Gambela; Harari; Addis Ababa and Dire Dawa. In general, the DHS sample is stratified, clustered and selected in two stages. In the 2005 EDHS a representative sample of approximately 14,500 households from 540 clusters was selected. The sample was selected in two stages. In the first stage, 540 clusters (145 urban and 395 rural) were selected from the list of enumeration areas (EA) from the 1994 Population and Housing Census sample frame. A total of 5,280 children less than 59 months were identified in the households of selected clusters.

From 5,280 children aged less than 59 months only 3095 of them are measured for anthropometric measurements height and weight. Thus, the analysis presented in this study on nutritional status is based on the 3095 children aged less than 59 months with complete anthropometric measurements.

#### 3.2 Variables included in the study

As it is demonstrated in the literature review socio-economic, demographic, health and environmental characteristics' are thought to be proximate determinants of nutritional status.

### **a. The Response variable**

The response variable of the study is stunting which is a dichotomous variable categorized into two: those children who are exposed to the event (i.e. stunted) and those who are not exposed to the event (i.e. not stunted).

In this study, height and weight measurements of children, taking age into consideration, were converted into Z-scores based on the National Center for Health Statistics (NCHS) reference population recommended by the World Health Organization (WHO). Thus, those below -2 standard deviations of the NCHS median reference for height-for-age, weight-for-age and weight-for-height are defined as stunted; underweight, and wasted, respectively. All the three indicators are used to describe the level of child malnutrition. Low height-for-age, or stunting, measures linear growth retardation and cumulative growth deficit and indicates the effect of past or chronic nutritional status in the life of the child. Therefore, an in-depth analysis was performed on stunting, focusing on factors affecting chronic malnutrition.

### **b. Explanatory variables**

The predictor variables to be analyzed as determinants of nutritional status of children are grouped into socio-economic, demographic, health and environmental factors.

#### **i. Socio-Economic Characteristics**

It is evident that socio-economic status of mothers' has strong relationship with chronic malnutrition. As proxy indicators of socioeconomic status of mothers' the following factors are included education, household income, place of residence and region.

#### **ii. Demographic Characteristics**

Demographic characteristics include age of the child, sex of the child, birth interval and birth order. While some of these demographic variables may have positive relationship with nutritional status others may exert negative influence.

### iii. Health and Environmental Characteristics

There are certain health and environmental characteristics that may increase or decrease the risk of malnutrition among children. Water supplies and toilet facilities are important health and environmental factors included in this study.

#### C. Description and Coding of the Study Variable

Detail description of socioeconomic, demographic, health and environmental related variables related to child nutritional status are presented as follows.

No.	Description and Name	Categories
1	Nutritional status	(0) Not Stunted (1) Stunted
2	Place of residence(RESIDENCE)	(0) Rural (1) Urban
3	Region(REGION)	(1) Tigray (2) Affar (3) Amhara (4) Oromiya (5) Somali (6) Ben-Gumuz (7) SNNP (8) Gambela (9) Harari (10) Addis Ababa (11) Dire-Dawa
4	Education of mother (EDUCMOTH)	(0) Illiterate (1) Literate
5	Education of partner (EDUCPART)	(0) Illiterate

		(1) Literate
6	Employment status of mother (EMPLMOTH)	(0) Unemployed (1) Employed
7	Employment status of partner (EMPOPART)	(0) Agriculture (1) Non agriculture
8	Economic status of the household (HE)	(0) Poor (1) Medium/higher
9	Sex of household head (SEXHH)	(0) Female (1) Male
10	Age of child (AGECHILD)	(0) <6 (1) 6-11 (2) 12-23 (3) 24-35 (4) 36-47 (5) 48-59
11	Sex of child (SEXCHILD)	(0) Female (1) Male
12	Birth order of the child (BORD)	(0) 1 (1) 2-3 (2) 4-5 (3) 6+
13	Preceding birth interval (BIRTH)	(0) <24 months (1) 24-35 months (2) 36-47 months (3) 48 and more months
14	Source of water supply (WATER)	(0) Unprotected

		(1) Protected
15	Availability of toilet facility (TOILET)	(0) No facility (bush, field) (1) Have facility (pit, flush, improved)
16	Had diarrhea in the two weeks before survey (DIARRHEA)	(0) Yes (1) No

### **3.3 Methodology**

Multivariate and multilevel statistical techniques can be used to predict a binary dependent variable from a set of independent variables. Multiple logistic regression analysis is used to study the net effects of each independent variable estimated controlling other factors on the dependent variable, nutritional status of children. The estimated coefficients tell us the increased or decreased chance of malnutrition given a set level of the independent variable while controlling for the effects of the other variables in the model. Estimates of odds ratio greater than 1.0 indicate that the risk of stunting is greater in a category than that for the reference category. Estimates less than 1.0 indicate that the risk of stunting is less than that for the reference category of each variable. Multilevel analysis is also employed to identify the determinants of malnutrition in children within regions as well as between regions within a single analysis. This can be expressed by statistical models with random coefficients.

#### **3.3.1 Introduction to Logistic Regression Analysis**

Regression methods have an integral component of any data analysis concerned with describing the relationship between a response variable and one or more explanatory variables. It is often the case that the outcome variable is discrete, taking on two or more values. When the outcome variable is binary or dichotomous many distribution functions have been proposed for use. Logistic regression model can be used mainly for two reasons. The first is from a mathematical point of view, it is an extremely flexible and easily used function, and the second it leads it self to meaningful interpretation.

##### **i. The Multiple Logistic Regression Model**

The logistic regression model can have an arbitrary number of parameters and terms in the model representing qualitative variables, quantitative variables, and interaction terms in order to model dichotomous or categorical outcome variable. When explanatory variables are included to model probabilities, a problem is that probabilities are restricted to the domain between 0 and 1, whereas a linear effect for an explanatory variable could

take the fitted value outside this interval. Instead of the probability of some event, one may consider the odds: the ratio of the probability of success to the probability of failure. When the probability is  $p$ , the odds are  $p/(1-p)$ . In contrast to probabilities, odds can assume any value from 0 to infinity, and odds can be considered to constitute a ratio scale.

The *logarithm* transforms a multiplicative to an additive scale and transforms the set of positive real numbers to the whole real line. Indeed, one of the most widely used transformations of probabilities is the *log odds*, defined by

$$\text{logit}(p) = \ln\left(\frac{p}{1-p}\right),$$

Where  $\ln(x)$  denotes the natural logarithm of the number  $x$ . The logit function is an increasing function defined for numbers between 0 and 1, and its range is from minus infinity to plus infinity. The logistic regression model is a model where  $\text{logit}(p)$  is a linear function of the explanatory variables.

For a binary response variable, the logit transformation of success probability,  $p_i$  of the  $i^{\text{th}}$  individual can be modeled as a linear combination of  $k$  explanatory variables  $X_{1i}$ ,  $X_{2i}$ , ...,  $X_{ki}$ , so that

$$\text{logit}(p_i) = \log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki}.$$

This implies

$$p_i = \frac{e^{\beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki}}}{1 + e^{\beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki}}}.$$

Where a model parameter  $\beta_i$  will be interpreted as the change in the log odds for a one unit increase in  $x_i$ , holding all the other predictor constant, or after adjusting for the other predictors. In order to estimate the parameters, maximum likelihood based

iteration algorithms can be employed. In spite of the attractive properties of the logit function, it is by no means the only suitable function for transforming probabilities to arbitrary real values. The general term for such a transformation function is the *link function*, as it links the probabilities (or more generally, the expected values of the dependant variable) to the explanatory variables. Detail discussion on logistic regression can be found in Agresti (1996) among others.

## ii. Test of Goodness Fit

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

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

$$\hat{C} = \frac{\sum_{k=1}^g (O_k - E_k)^2}{V_k}, \quad \text{where} \quad E_k = nP_k \quad \text{and} \quad V_k = nP_k(1 - P_k)$$

where  $g$  is the number of group,  $O_k$  is observed number of events in the  $\kappa^{\text{th}}$  group,  $E_k$  is expected number of events in  $\kappa^{\text{th}}$  group, and  $V_k$  is a variance correction factor for the  $\kappa^{\text{th}}$  group. If the observed number of events differs from what is expected by the model, the statistic  $\hat{C}$  will be large and there will be evidence against the null hypothesis that the model is adequate to fit the data. This statistic has an approximate chi-square distribution with  $(g - 2)$  degrees of freedom.

The Wald statistic is also an alternative test which is commonly used to test the significance of individual logistic regression coefficients for each independent variable (that is, to test the null hypothesis in logistic regression that a particular logit (effect) coefficient is zero i.e.  $H_0: \beta_i = 0$  against  $\beta_i \neq 0$ ). For a dichotomous independent

variable, the Wald statistic (W) is

$$W = \frac{\hat{\beta}_i^2}{\text{var}(\hat{\beta}_i)}.$$

For large sample size this statistic has an approximate chi-square distribution with one degree of freedom.

### **3.3.2 Multilevel Analysis**

#### **3.3.2.1 Introduction**

Multilevel analysis is a methodology for the analysis of data with complex patterns of variability, with a focus on nested sources of variability. The best way to the analysis of multilevel data is an approach that represents within-group as well as between group relations within a single analysis, where ‘group’ refers to the units at the higher levels of the nesting hierarchy. Very often it makes sense to use probability models to represent the variability within and between groups, in other words, to conceive of the unexplained variation within groups and the unexplained variation between groups as random variability. For example, a study of children within regions means that not only unexplained variation between children, but also unexplained variation between regions is regarded as random variable. This can be expressed by statistical models called random coefficient. Multilevel analysis is an approach to the analysis of such data including the statistical techniques as well as the methodology of how to use these.

Multilevel analysis is a stream which has two tributaries: contextual analysis and mixed effects models. Contextual analysis is a development in the social sciences which has focused on the effects of the social context on individual behavior whereas mixed effects models are statistical models in the analysis of variance and in regression analysis where it is assumed that some of the coefficients are fixed and others are random.

The main statistical model of multilevel analysis is the hierarchical generalized linear model, an extension of the generalized linear model that includes nested random coefficients.

### 3.3.2.2 Hierarchical generalized linear model

Important instances of discrete dependant variables are dichotomous variables (e.g., success vs. failure of whatever kind) and counts (e.g., in the study of some kind of event, the number of events happening in a predetermined time period). For example, a dichotomous variable can be represented as having the values 0 and 1. It may not be appropriate to apply linear regression methods to such variable for two reasons.

The first reason is that the range of such a dependant variable is restricted, and the usual linear regression model might take its fitted value outside this allowed range, that is a meaningful model for outcomes that have only the values 0 and 1 should not allow fitted values that are negative or greater than 1.

The second reason is the fact for discrete variables where there is often some natural relation between the mean and the variance of the distribution. For example, for a dichotomous variable  $Y$  that has probability  $p$  for outcome 1 and probability  $1-p$  for outcome 0, the mean is

$$E(Y) = p$$

and the variance is

$$\text{var}(Y) = p(1 - p). \quad (3.1)$$

Thus, the variance is determined by the mean. In terms of multilevel modeling, this leads to the development of regression-like models that are more complicated than the usual multiple linear regression model and that take account of the non-normal distribution of the dependant variable, its restricted range, and the relation between mean and variance. The best known method of this kind is multilevel logistic regression, a regression like-model for dichotomous data. In general, multilevel versions of generalized linear models are called hierarchical generalized linear models. The next section presents a multilevel version of logistic regression.

### 3.3.2.3 Introduction to Multilevel Logistic Regression

Consider a population having two levels. The basic data structure of two-level logistic regression is a collection of  $N$  groups (units at level two) and within group  $j$  ( $j=1, 2, \dots, N$ ) a random sample of  $n_j$  level-one units (individuals). The outcome variable is dichotomous and denoted by  $Y_{ij}$  ( $i=1,2, \dots, n_j, j=1,2, \dots, N$ ) for level-one unit  $i$  in group  $j$ . The two outcomes are supposed to be coded 0 and 1: 0 for 'failure', 1 for 'success'. The total sample size is denoted by  $M = \sum_{j=1}^N n_j$ . If one does not take explanatory variables into account, the probability of success is assumed constant in each group.

Let the success probability in group  $j$  is denoted by  $P_j$ . The dichotomous outcome variable for individual  $i$  in group  $j$ ,  $Y_{ij}$ , which is either 0 or 1, can be expressed as the sum of the probability in group  $j$ ,  $P_j$  ( the average proportion  $j$ - levels in group  $j$ ,  $E(Y_{ij}) = P_j$ ) plus some individual-dependent residual,  $\varepsilon_{ij}$ .

$$Y_{ij} = P_j + \varepsilon_{ij} . \quad (3.2)$$

The residual term is assumed to have mean zero and variance,

$$\text{var}(\varepsilon_{ij}) = P_j(1 - P_j) . \quad (3.3)$$

Since the outcome variable is coded 0 and 1, the group sample average is the proportion of successes in group  $j$  given by

$$\hat{P}_j = \frac{1}{n_j} \sum_{i=1}^{n_j} Y_{ij} . \quad (3.4)$$

$\hat{P}_j$  is an estimate for the group-dependant probability  $P_j$ . Similarly, the overall sample average is the overall proportion of successes,  $\hat{P}_.$ , and is given by

$$\hat{P} = \frac{1}{M} \sum_{j=1}^N \sum_{i=1}^{n_j} Y_{ij}. \quad (3.5)$$

This is an estimate for the overall probability of success,  $P$ . An estimator of the variance of  $P_j$  can be obtained by using

$$\hat{\tau}^2 = S_{between}^2 - \frac{S_{within}^2}{\tilde{n}}, \quad (3.6)$$

where

$$\tilde{n} = \frac{1}{N-1} \left\{ M - \frac{\sum_{j=1}^N n_j^2}{M} \right\},$$

$$S_{between}^2 = \frac{\hat{P} \cdot (1 - \hat{P})}{\tilde{n}(N-1)} X^2, \quad \text{Where } X^2 \text{ is as given by equation (3.7)}$$

$$S_{within}^2 = \frac{1}{M-N} \sum n_j P_j (1 - P_j),$$

### a. Heterogeneous Proportion

For the proper application of multilevel analysis the first logical step is to test heterogeneity of proportions between the groups. Here we presented two commonly used test statistics. To test whether there are indeed systematic differences between the groups, the well-known chi-square test for contingency table can be used. In this case the chi-square test can be written as

$$X^2 = \sum_{j=1}^N n_j \frac{(\hat{P}_j - \hat{P})^2}{\hat{P}(1 - \hat{P})}. \quad (3.7)$$

This statistic follows approximately chi-squared distribution with  $N-1$  degrees of

freedom. The approximation is valid if the expected numbers of success and of failures in each group,  $n_j \hat{P}_j$  and  $n_j(1 - \hat{P}_j)$ , respectively, are at least 1 while 80 percent of them are at least 5 (Agresti, 1990, p. 246). This condition will not always be satisfied, and the chi-squared test then may be seriously in error. For a large number of groups the null distribution of  $X^2$  can be approximated by a normal distribution with the correct mean and variance, McCullagh and Nelder (1989).

Another test of heterogeneity of proportion was proposed by Commenges and Jacqmin (1994). The test statistic is

$$Z = \frac{\sum_{j=1}^N \{n_j^2 (n_j \hat{P}_j - \hat{P})^2\} - M\hat{P}(1 - \hat{P})}{\hat{P}(1 - \hat{P}) \sqrt{2 \sum_{j=1}^N n_j (n_j - 1)}}. \quad (3.8)$$

The statistic,  $Z$ , tends to follow a standard normal distribution. Thus, large values of this statistic are indication of heterogeneous proportions.

In the statistic  $Z$  the numerator contains a weight of  $n_j^2$  whereas chi-squared test uses a weight  $n_j$ , these shows that the two tests combine the groups in different ways. Hence, when the group sizes  $n_j$  are different, it is possible that the two test lead to different outcomes. The statistic  $Z$  has shown to have high power over the chi-square test and it can be applied whenever there are many groups, even with small group sizes, provided that no single group dominates.

### **b. Multilevel Logistic Regression**

Multilevel logistic regression can be employed in the simplest case without explanatory variables, (usually called empty model) and also with explanatory variables by allowing only the intercept term or both the intercept and slopes (regression coefficients) to vary randomly. Mainly the normal (multivariate normal) distribution is assumed for the varying coefficients. To keep the discussion on multilevel logistic regression models simple and taking into account the data to be analyzed in this study we concentrate on

the case of two-levels. We note that extensions to the case of three or higher levels is straight forward (see, Snijders and Bosker, 1999).

### **i. The empty logistic Regression model**

The empty two-level model for a dichotomous outcome variable refers to population of groups (level-two units) and specifies the probability distribution for the group-dependant probabilities  $P_j$  in (3.2), without taking further explanatory variables into account. Several such specifications have been proposed. We focus on the model that specifies the transformed probabilities  $f(P_j)$  to have a normal distribution. This is expressed, for a general link function  $f(p)$ , by the formula

$$f(P_j) = \beta_0 + U_{0j} , \quad (3.9)$$

where  $\beta_0$  is the population average of the transformed probabilities and  $U_{0j}$  the random deviation from this average for group  $j$ . If  $f(p)$  is the *logit* function, then  $f(P_j)$  is just the log-odds for group  $j$ . Thus, for the *logit* link function, the log-odds have a normal distribution in the population of groups, which is expressed by

$$\text{logit}(P_j) = \beta_0 + U_{0j} . \quad (3.10)$$

For the deviations  $U_{0j}$  it is assumed that they are independent random variables with a normal distribution with mean 0 and variance  $\sigma_0^2$ .

This model does not include a separate parameter for the level-one variance. This is because the level-one residual variance of the dichotomous outcome variable follows directly from the success probability, as indicated by equation (3.3).

Denote by  $\pi_0$  the probability corresponding to the average value  $\beta_0$ , as defined by

$$f(\pi_0) = \beta_0 .$$

For the logit function, this means that  $\pi_0$  is the so-called logistic transformation of  $\beta_0$ ,

defined by

$$\pi_0 = \text{logistic}(\beta_0) = \frac{\exp(\beta_0)}{1 + \exp(\beta_0)}. \quad (3.11)$$

Note that because of the non-linear nature of the logit link function, there is no a simple relation between the variance of the probabilities,  $P_j$ 's and the variance of the deviations  $U_{0j}$ . However, there is an approximate formula which is valid when the variances are small and is given by

$$\text{var}(P_j) \approx (\pi_0(1 - \pi_0))^2 \sigma_0^2. \quad (3.12)$$

Note that an estimate of population variance  $\text{var}(P_j)$  can be obtained by replacing sample estimates of  $\pi_0$  and  $\sigma_0^2$ . The resulting approximation can be compared with the nonparametric estimate,  $\hat{\tau}^2$ , given in (3.6).

## ii. The Random Intercept Logistic Regression Model

In logistic regression analysis, linear models are constructed for the log-odds. The multilevel analogue, random coefficient logistic regression, is based on linear models for the log-odds that include random effects for the groups or other higher-level units. As mentioned above,  $Y_{ij}$  denotes the dichotomous outcome variable for level-one unit  $i$  in level-two unit  $j$ . We will use the terms ‘individual’ and ‘group’ to refer to the level-one units and level-two units, respectively.

Consider explanatory variables which are potential explanations for the observed outcomes. Denoted these variables by  $X_1$  to  $X_k$ . The values of  $X_h$  ( $h=1,2,\dots,\kappa$ ) are indicated in the usual way by  $x_{hij}$ . Since some or all of these variables could be level-one variables, the success probability is not necessarily the same for all individuals in a given group. Therefore, the success probability depends on the individual as well as on the group, and is denoted by  $P_{ij}$ . In a similar way as in (3.2) the outcome variable is expressed as the sum of success probability (expected value of the outcome variable) and

a residual term,  $\varepsilon_{ij}$ . That is,

$$Y_{ij} = P_{ij} + \varepsilon_{ij}. \quad (3.13)$$

The residuals  $\varepsilon_{ij}$  are assumed to have mean zero and variance  $\sigma_{\varepsilon}^2$ .

The logistic random intercept model expresses the log-odds, i.e., the logit of  $P_{ij}$ , as a sum of a linear function of the explanatory variables. That is,

$$\log it(P_{ij}) = \log\left(\frac{P_{ij}}{1-P_{ij}}\right) = \beta_{0j} + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \dots + \beta_k x_{kij},$$

where the intercept term  $\beta_{0j}$  is assumed to vary randomly and given by the sum of an average intercept  $\beta_0$  and group dependant deviations  $U_{0j}$ , that is

$$\beta_{0j} = \beta_0 + U_{0j}$$

As a result

$$\log it(P_{ij}) = \beta_0 + \sum_{h=1}^k \beta_h x_{hij} + U_{0j}. \quad (3.14)$$

Solve for  $P_{ij}$

$$P_{ij} = \frac{e^{\beta_0 + \sum_{h=1}^k \beta_h x_{hij} + U_{0j}}}{1 + e^{\beta_0 + \sum_{h=1}^k \beta_h x_{hij} + U_{0j}}},$$

Thus, a unit difference between the  $X_h$  values of two individuals in the same group is associated with a difference of  $\beta_h$  in their log-odds, or equivalently, a ratio of  $\exp(\beta_h)$  in their odds. Equation (3.14) does not include a level-one residual because it is an equation for the probability  $P_{ij}$  rather than for the outcome  $Y_{ij}$ . The level-one residual is already included in (3.13).

Note that the first part of the right-hand side of (3.14), incorporating the regression coefficients,  $\beta_0 + \sum_{h=1}^{\kappa} \beta_{hj} x_{hij}$  is the *fixed part* of the model, because the coefficients are *fixed*. The remaining part,  $U_{0j}$ , is called the *random part* of the model. It is assumed that the residual,  $U_{0j}$ , are mutually independent and normally distributed with mean zero and variance  $\sigma_0^2$ .

### iii. The Random Coefficients Logistic Regression Model

In the random intercept logistic regression model the intercept is the only random effect meaning that the groups differ with respect to the average value of the dependant variable. But the relation between explanatory and dependent variables can differ between groups in more ways. For example, in the study of nutritional status (nesting structure: children within regions), it is possible that the effect of socio-economic status on children nutritional status is higher in some regions than in others. In the analysis of covariance, this phenomenon is known as heterogeneity of regressions across groups, or as group-by-covariate interaction. In the hierarchical linear model, it is modeled by random coefficients.

Now consider a model with group-specific regressions of *logit* of the success probability,  $\log it(P_{ij})$ , on a single level-one explanatory variable  $X$ ,

$$\log it(P_{ij}) = \log\left(\frac{P_{ij}}{1-P_{ij}}\right) = \beta_{0j} + \beta_{1j} x_{1ij}. \quad (3.15)$$

The intercepts  $\beta_{0j}$  as well as the regression coefficients, or slopes,  $\beta_{1j}$  are group-dependent. These group-dependant coefficients can be split into an average coefficient and the group-dependant deviation:

$$\begin{aligned} \beta_{0j} &= \beta_0 + U_{0j}, \\ \beta_{1j} &= \beta_1 + U_{1j}. \end{aligned} \quad (3.16)$$

Substitution into (3.15) leads to the model

$$\begin{aligned}\log it(P_{ij}) &= \log\left(\frac{P_{ij}}{1-P_{ij}}\right) = (\beta_0 + U_{0j}) + (\beta_1 + U_{1j})x_{1ij} \\ &= \beta_0 + \beta_1 x_{1ij} + U_{0j} + U_{1j} x_{1ij} .\end{aligned}\tag{3.17}$$

There are two random group effects, the random intercept  $U_{0j}$  and the random slope  $U_{1j}$ . It is assumed that the level-two residuals  $U_{0j}$  and  $U_{1j}$  have means zero given the value of the explanatory variable  $X$ . Thus,  $\beta_1$  is the average regression coefficient like  $\beta_0$  is the average intercept. The first part of (3.17),  $\beta_0 + \beta_1 x_{1ij}$ , is called the fixed part of the model and the second part of,  $U_{0j} + U_{1j} x_{1ij}$ , is called the random part.

The term  $U_{1j} x_{1ij}$  can be regarded as a *random interaction between group and  $X$* . This model implies that the groups are characterized by two random effects: their intercept and their slope. These two group effects  $U_{0j}$  and  $U_{1j}$  will not be independent, but correlated. Further, it is assumed that, for different groups, the pairs of random effects  $(U_{0j}, U_{1j})$  are independent and identically distributed. Thus, the variances and covariance of the level-two random effects  $(U_{0j}, U_{1j})$  are denoted as follows:

$$\begin{aligned}\text{var}(U_{0j}) &= \sigma_{00} = \sigma_0^2; \\ \text{var}(U_{1j}) &= \sigma_{11} = \sigma_1^2; \\ \text{cov}(U_{0j}, U_{1j}) &= \sigma_{01}.\end{aligned}\tag{3.18}$$

The model for single explanatory variable discussed above can be extended by including more variables that have random effects. Suppose that there are  $\kappa$  level-one explanatory variables  $X_1, X_2, \dots, X_\kappa$  and consider the model where all  $X$ -variables have varying slopes and random intercept. That is

$$\log it(P_{ij}) = \log\left(\frac{P_{ij}}{1-P_{ij}}\right) = \beta_{0j} + \beta_{1j}x_{1ij} + \beta_{2j}x_{2ij} + \dots + \beta_{\kappa j}x_{\kappa ij} .\tag{3.19}$$

Letting

$$\beta_{0j} = \beta_0 + U_{0j} \quad \text{and} \quad \beta_{hj} = \beta_h + U_{hj},$$

$$h=1,2,\dots,k.$$

we have from (3.19)

$$\log it(P_{ij}) = \log\left(\frac{P_{ij}}{1-P_{ij}}\right) = \beta_0 + \sum_{h=1}^k \beta_h X_{hij} + U_{0j} + \sum_{h=1}^k U_{hj} X_{hij}. \quad (3.20)$$

The first part of (3.20),  $\beta_0 + \sum_{h=1}^k \beta_h X_{hij}$ , is called the fixed part of the model. The second part,  $U_{0j} + \sum_{h=1}^k U_{hj} X_{hij}$ , is called the random part.

The groups are characterized by  $\kappa + 1$  random coefficients  $U_{0j}, U_{1j}, U_{2j}, \dots, U_{kj}$ . These random coefficients are independent between groups, but may be correlated within groups. It is assumed that the vectors  $(U_{0j}, \dots, U_{kj})$  is independently distributed with means zero and has a multivariate normal distribution with a constant covariance matrix. The variances and covariances of the level-two random effects are denoted by

$$\text{var}(U_{hj}) = \sigma_{hh} = \sigma_h^2 \quad , \quad h = 0,1,2,\dots,k,$$

$$\text{cov}(U_{hj}, U_{pj}) = \sigma_{hp} \quad , \quad p = 0,1,2,\dots,k. \quad \text{for } h \neq p$$

We note that parameter estimation in hierarchical generalized linear models is more complicated than the hierarchical linear models. Inevitably some kind of approximation is involved, and various kinds of approximation have been proposed. The most frequently used methods are based on a first-order or second-order Taylor series expansion of the link function. Another method is the use of numerical integration. These methods of estimation are implemented in various softwares like LISREL and MLwiN among others. In this study, the multilevel data analysis is supported by the

software LISREL.

## CHAPTER FOUR

### STATISTICAL DATA ANALYSIS

#### **4.1 Major socioeconomic, demographic, health and environmental characteristics with nutritional status of children**

The major socioeconomic, demographic, health and environmental background characteristics of the respondents and children are presented in table 4.1. The total number of children covered in the present study is 3095. Among these, 1400 (45.2 percent) were found to be stunted whereas 1695 (54.8 percent) were not stunted.

The proportion of stunted children, as can be seen in Table 4.1, differs by type of place of residence: urban and rural. Accordingly, nearly half of the stunted children (47.9 percent) reside in rural areas unlike the relatively smaller number of stunted children (23.5 percent) who reside in urban centers. Moreover, the nutritional status of children varied from one region to the other. For example, the highest prevalence of child-stunting was observed in Amhara (58.5 percent) followed by SNNP (52.4 percent) as opposed to the lowest prevalence which was recorded in Addis Ababa (20.5 percent) and followed by Dire Dawa (28.5 percent). Moreover, region-wise urban-rural difference in Ethiopia showed that in all the regions, higher prevalence of stunting was observed in rural parts than urban centers.

Likewise, it is evident that educational status of mothers under consideration is an important variable as determinant of child stunting. As Table 4.1 portrays, the proportion of stunted children whose mothers are illiterate is 47.6 percent unlike the proportion of stunted children whose mothers are literate is 36.2 percent. The literacy status of partners (husbands) has almost similar pattern with that of the literacy status of the mothers (wives). It is found out that higher proportion of stunted children whose partners are illiterate is higher than those whose mothers are literate.

The prevalence of stunting among children from poor households (46.5 percent) is higher than children from medium or higher economic status households (18.8 percent). Among other socioeconomic factors, employment status of mothers was also important

and the prevalence of stunting was higher among children of employed mothers (48.1 percent) as compared to the prevalence of stunting among children of unemployed mothers (44.0 percent). Regarding partner's employment status, those working in agricultural sector show higher prevalence of child stunting (47.9 percent) than those in non-agricultural (31.0 percent).

The demographic variables like age of the child, birth order and preceding birth interval were found to be important variables as determinants of child nutritional status. The highest proportion of stunted children was observed among age group 36-47 months (52.9 percent) followed by age group 12-23 months (52.7 percent) and age group less than 48-59 months (49.8 percent); while child stunting was lowest in the youngest age group of less than 6 months (8.4 percent), followed by age groups 6-11 months (26.8 percent). The highest level of stunting was also observed among children whose birth order was 6 and more (47.0 percent), followed by birth order 4 or 5 (45.6 percent) and it was lowest at first born ones (42.6 percent) (Table 4.1).

With regards to preceding birth interval of children, the highest proportion of stunted children were observed among those whose preceding birth interval was less than 24 months. A smaller percentage (42.6 percent) of children of low birth order (1) is stunted compared to those of higher birth orders. The sex distribution of children shows that males and females account for 46.6 percent and 43.8 percent respectively. The result indicated that females are less affected by stunting than males; the table shows the prevalence of stunting is higher for males than females.

As indicated in different studies, health and environmental characteristics of households play role on the nutritional status of children. The source of water supply and the availability of toilet facilities are important determinants of the nutritional status of children (Table 4.1). The prevalence of stunting children of household with unprotected water source and with no toilet facility is higher as compared with those who have. The proportion of child stunting among those who had diarrhea in the two weeks before the survey date is slightly higher as compared to those who have not.

Table 4.1 **Distribution of socioeconomic and demographic, health and environmental related characteristics and children nutritional status**

Background characteristic	Urban			Rural			Total		
	Number of stunted children	Percent	Total no. of children	Number of stunted children	Percent	Total	Number Of stunted children	Percent	Total
<b>Residence</b>									
Rural							1320	47.9	2755
Urban							80	23.5	340
<b>Region</b>									
Tigray	6	40.0	15	154	45.6	338	160	45.3	353
Afar	1	5.3	19	76	47.5	160	77	43.0	179
Amhara	10	52.6	19	230	58.8	391	240	58.5	410
Oromiya	10	37.0	27	269	43.7	616	279	43.4	643
Somali	11	37.9	29	84	50.0	168	95	48.2	197
Ben-Gumz	4	23.5	17	91	41.0	222	95	39.7	239
SNNP	9	25.0	36	286	54.3	527	295	52.4	563
Gambela	1	4.0	25	43	36.1	119	44	30.6	144
Harari	11	33.3	33	51	41.5	123	62	39.7	156
Dire Dawa	6	13.3	45	29	37.2	78	35	28.5	123
Addis Ababa	11	14.7	75	7	53.8	13	18	20.5	88
<b>Education of mother</b>									
Illiterate	36	27.9	129	1134	48.6	2331	1170	47.6	2460
Literate	44	20.9	211	186	43.9	424	230	36.2	635
<b>Education of partner</b>									
Illiterate	24	27.9	86	895	49.4	1812	919	48.4	1898
Literate	56	22.0	254	425	45.1	943	481	40.2	1197
<b>Employment status of partner</b>									
Agriculture	10	34.5	29	1239	48.0	2579	1249	47.9	2608
Non-agriculture	70	22.5	311	81	46.0	176	151	31.0	487
<b>Employment status of mother</b>									
Unemployed	42	20.4	206	905	46.5	1947	947	44.0	2153
Employed	38	28.4	134	415	51.4	808	453	48.1	942
<b>Economic status of the Household</b>									
Poor	61	27.7	220	1312	48.0	2731	1337	46.5	2951
Medium or higher	19	15.8	120	8	33.3	24	27	18.8	144
<b>Sex of household head</b>									
Female	16	20.0	80	151	47.3	319	167	41.9	399
Male	64	24.6	260	1169	48.0	2436	1233	45.7	2696
<b>Age of child</b>									
<6	1	3.7	27	20	8.9	224	21	8.4	251
6-11	6	15.0	40	78	28.6	273	84	26.8	313
12-23	19	29.2	65	298	55.5	537	317	52.7	602
24-35	18	24.7	73	272	52.8	515	290	49.3	588
36-47	13	22.0	59	332	56.0	593	345	52.9	652

48-59	23	30.3	76	320	52.2	613	343	49.8	689
<b>Sex of child</b>									
Female	36	20.3	177	627	47.0	1335	663	43.8	1512
Male	44	27.0	163	693	48.8	1420	737	46.6	1583
<b>Birth order of the child</b>									
1	11	16.2	68	236	46.1	512	247	42.6	580
2-3	32	30.2	106	411	46.9	877	443	45.1	983
4-5	20	28.6	70	304	47.4	641	324	45.6	711
6+	17	17.7	96	369	50.9	725	386	47.0	821
<b>Preceding birth interval</b>									
<24 months	18	36.0	50	303	52.3	579	321	51.0	629
24-35 months	22	25.9	85	514	49.7	1034	536	47.9	1119
36-47 months	16	21.1	76	295	44.4	665	311	42.0	741
48 and more months	24	18.6	129	208	43.6	477	232	38.3	606
<b>Source of drinking water</b>									
Unprotected	8	25.0	32	639	50.7	1260	647	50.1	1292
Protected	72	23.4	308	681	45.6	1495	753	41.8	1803
<b>Availability of toilet facility</b>									
No facility	16	27.1	59	953	47.3	2016	969	46.7	2075
Facility	64	22.8	281	367	49.7	739	431	42.3	1020
<b>Had diarrhea recently</b>									
Yes	11	22.0	50	279	51.1	546	290	48.7	596
No	69	23.8	290	1041	47.1	2209	1110	44.4	2499
<b>Total</b>									3095

## 4.2 Determinants of Stunting in Children: A Logistic Regression Analysis

Multiple logistic regression analysis was used to examine the effect of each independent variable in the model for stunting in children, while controlling the other independent variable. Three different models are fitted in this study to see the basic determinants of stunting among children aged less than 59 months. The first model (Urban Model) was fitted to identify the determinants of stunting for urban children. Whereas, the second model (Rural Model) demonstrates the socio-economic and demographic determinants of stunting among children living in rural Ethiopia. Similarly, the third model was fitted to identify the basic determinants of stunting for national level including urban and rural children together in Ethiopia. All these models were formulated in line with the objectives of the EDHS of 2005 which was meant to provide estimates for the country as a whole and for urban and rural areas separately.

#### 4.2.1 Goodness of Fit Test

Goodness of fit test for the fitted multiple logistic regression models was assessed using the Hosmer and Lemeshow test and deviance based chi-square test. Accordingly, the Hosmer and Lemeshow test for the urban, rural, and combined national sample models resulted in p-values of 0.733, 0.273, and 0.800, respectively, which tell us the models adequately fit the data at 0.05 level of significance.

Similarly, the deviance based chi-square test provided chi-square value of 59.102 ( $p < 0.01$ ), 319.63 ( $p < 0.01$ ) and 431.528 ( $p < 0.01$ ) which would imply good fit for the urban, rural, and combined models, respectively. Model diagnostic checks presented in the appendix do not show strict violation of model assumption.

#### 4.2.2 Determinants of Stunting among Urban Children in Ethiopia

The most important explanatory variables of nutritional status in urban children are identified using forward selection in logistic regression. In urban model, region of residence, household economic status and age of the child were found to be determinants of stunting among urban children. Results of all variables in the logistic regression are presented in appendix using enter method. The estimated coefficient ( $\hat{\beta}_i$ 's) for the covariates in the final model, their standard error ( $S.E.(\hat{\beta})$ ) and the odds ratio corresponding each estimated coefficient ( $\hat{\beta}_i$ ) of stunting among urban children aged less than 59 months by background characteristics are given in the following Table 4.2.

The urban sample showed that, as compared with children in Addis Ababa region, children in Tigray and Amhara regions were 5.84 and 4.76 times more likely to be stunted, respectively. The result also shows that urban children from poor socioeconomic status of households are 3.0 times more likely at risk of stunting than children in medium or higher household economic status category. Moreover in urban areas, children in the age group less than 6 months and 6-11 months were found to be at lower odds of stunting as compared with children in the age group 48-59 months. The odds of stunting in the age groups less than 6 months and 6-11 months are less than 0.072 and 0.310 times lower for children in the age groups 48-59 months.

Table 4.2 Important Variables in the Urban Model

Covariates	Urban					
	$\hat{\beta}$	<i>S.E.</i> ( $\hat{\beta}$ )	Wald	<i>df</i>	p-value	<i>Exp</i> ( $\hat{\beta}$ )
<b>Region</b>			28.943	10	0.001*	
Tigray	1.764	0.693	6.491	1	0.011*	5.839
Afar	-1.338	1.096	1.490	1	0.222	0.262
Amhara	1.561	0.584	7.137	1	0.008*	4.763
Oromiya	1.171	0.537	4.756	1	0.029*	3.225
Somali	0.955	0.536	3.176	1	0.075	2.599
Ben-Gumz	0.381	0.687	0.307	1	0.580	1.463
SNNP	0.354	0.537	0.435	1	0.510	1.425
Gambela	-1.763	1.087	2.632	1	0.105	0.171
Harari	1.347	0.527	6.534	1	0.011*	3.848
Dire Dawa	-0.186	0.562	0.109	1	0.741	0.831
Addis Ababa(ref)						1.000
<b>House hold Economic Status</b>						
Poor	1.100	0.355	9.588	1	0.002*	3.006
Medium or Higher(ref.)						1.000
<b>Age of child</b>			10.7	5	0.058	
<6	-2.626	1.084	5.868	1	0.015*	0.072
6-11	-1.171	0.540	4.711	1	0.030*	0.310
12-23	-0.039	0.406	0.009	1	0.924	0.962
24-35	-0.300	0.410	0.535	1	0.464	0.741
36-47	-0.491	0.441	1.2	1	0.265	0.612
48-59(ref.)						1
<b>Constant</b>	-2.036	0.454	20.090	1	0.000*	0.131

\* Significant (p<0.05)

ref. = reference category

#### 4.2.3 Determinants of Stunting among Rural Children in Ethiopia

Logistic regression analysis with forward variable selection procedure was also employed for rural children alone. The result showed that region of residence, employment status of mother, age of the child, preceding birth interval and source of drinking water found to be important predictors of nutritional status (Table 4.3). The rural model showed that children in Amhara and SNNP regions were 2.4 and 2.1 times more likely to be stunted as compared with children in Dire Dawa. The result also showed that children in the age group less than 6 months and 6-11 months were found to be at significantly lower risk of stunting as compared with children in the age group 48-

59 months. It was also observed that as the preceding birth interval of the child decreases, the likelihood of being stunted increase. Children whose preceding birth interval was less than 24 months were 1.389 times more likely to be stunted as compared with children of a preceding birth interval 48 months and more. The risk of stunting was also 1.389 times higher for children from households that use unprotected water as compared with children from households that use protected water.

Table 4.3 Selected Variables in the Rural Model

Covariates	Rural					
	$\hat{\beta}$	<i>S.E.</i> ( $\hat{\beta}$ )	Wald	<i>df</i>	p-value	<i>Exp</i> ( $\hat{\beta}$ )
<b>Region</b>			54.470	9	0.000*	
Tigray	0.222	0.270	0.673	1	0.412	1.248
Afar	0.362	0.298	1.470	1	0.225	1.436
Amhara	0.853	0.268	10.115	1	0.001*	2.346
Oromiya	0.246	0.258	0.908	1	0.341	1.279
Somali	0.414	0.297	1.943	1	0.163	1.513
Ben-Gumz	0.088	0.283	0.097	1	0.756	1.092
SNNP	0.749	0.261	8.229	1	0.004*	2.115
Gambela	0.164	0.315	0.271	1	0.603	0.849
Harari	0.138	0.309	0.200	1	0.655	1.148
Dire Dawa(ref.)						1.000
<b>Employment status of mother</b>						
Employment (ref)						1.000
Unemployed	-0.207	0.092	5.095	1	0.024*	0.813
<b>Age of child</b>			162.358	5	0.000*	
<6	-2.429	0.250	94.446	1	0.000*	0.088
6-11	-1.019	0.160	40.646	1	0.000*	0.361
12-23	0.144	0.121	1.416	1	0.234	1.155
24-35	0.037	0.122	0.093	1	0.760	1.038
36-47	0.159	0.118	1.8	1	0.179	1.172
48-59(ref)						1.000
<b>Preceding birth interval</b>			8.581	3	0.035*	
<24 months	0.329	0.133	6.087	1	0.014*	1.389
24-35 months	0.200	0.119	2.829	1	0.093	1.222
36-47 months	0.039	0.129	0.093	1	0.761	1.040
48 and more months(ref)						1.000
<b>Source of drinking water</b>						
Unprotected	0.214	0.085	6.402	1	0.011*	1.239
Protected(ref.)						
<b>Constant</b>	-0.424	0.281	2.284	1	0.131	0.654

\* Significant (p<0.05)

#### **4.2.4 Determinants of Stunting in Children at National level**

In this analysis the over all determinants of stunting were assessed to identify the basic determinant factors which were important for identifying children's nutritional status among children in the national level. The combined urban and rural (national) sample results should that type of place of residence, employment status of mother, household economic status, age of child, sex of child and source of drinking water were found to be important determinants in child nutritional status (Table 4.4). This model portrayed that the risk of being stunted was significantly higher for rural children (1.97 times) more than their urban counterparts. Children who reside in the Amhara region and SNNP region were 2.1 times more likely to be stunted than children in Addis Ababa. Children whose mothers employed were 1.2 times more likely to be stunted than children whose mothers were unemployed. Household economic status is also another important variable explaining child stunting. Children residing in poor households were 1.8 times more likely at a higher risk of stunting than children from medium or higher household economic status.

As compared with children in the age group 48-59 months, the risk of stunting was about 0.085 and 0.358 times lower for children in the age groups less than 6 and 6-11 months, respectively. Children whose preceding birth interval was less than 24 months were 1.421 times more likely to be stunted as compared with children whose preceding birth interval was 48 months and above. The risk of stunting was 1.2 times higher for children from households that use unprotected water as compared with children from households that use protected water. It was also observed that as the preceding birth interval of the child decrease the likelihood of being stunted increases.

Table 4.4 Selected Variables in the national level

Covariates	National Level					
	$\hat{\beta}$	$S.E.(\hat{\beta})$	Wald	$df$	p-value	$Exp(\hat{\beta})$
<b>Residence</b>						
Rural	0.680	0.167	16.671	1.000	0.000*	1.974
Urban(ref)						1.000
<b>Region</b>			65.283	10	0.000*	
Tigray	0.313	0.321	0.952	1	0.329	1.367
Afar	0.318	0.340	0.877	1	0.349	1.375
Amhara	0.930	0.318	8.553	1	0.003*	2.535
Oromiya	0.311	0.311	0.995	1	0.318	1.364
Somali	0.525	0.336	2.443	1	0.118	1.690
Ben-Gumz	0.115	0.330	0.122	1	0.727	1.122
SNNP	0.775	0.312	6.167	1	0.013*	2.170
Gambela	-0.239	0.351	0.462	1	0.497	0.788
Harari	0.351	0.339	1.071	1	0.301	1.420
Dire Dawa	-0.062	0.356	0.030	1	0.862	0.940
Addis Ababa(ref)						1.000
<b>Employment status of mother</b>						
Employment (ref)						1.000
Unemployed	-0.210	0.087	5.788	1	0.016*	0.811
<b>House hold Economic Status</b>						
Poor	0.638	0.256	6.190	1	0.013*	1.892
Medium or Higher(ref.)						1.000
<b>Age of child</b>			170.1	5	0.000*	
<6	-2.468	0.244	102.711	1	0.000*	0.085
6-11	-1.028	0.153	45.162	1	0.000*	0.358
12-23	0.123	0.116	1.127	1	0.288	1.131
24-35	-0.009	0.116	0.006	1	0.940	0.991
36-47	0.094	0.113	0.7	1	0.404	1.099
48-59(ref.)						1.000
<b>Sex of child</b>						
Female	-0.161	0.078	4.277	1.000	0.039*	0.852
Male(ref)						
<b>Preceding birth interval</b>			11.184	3.000	0.011*	
<24 months	0.351	0.126	7.804	1.000	0.005*	1.421
24-35 months	0.198	0.112	3.112	1.000	0.078	1.218
36-47 months	0.022	0.121	0.033	1.000	0.855	1.022
48 and more months(ref.)						1.000
<b>Source of drinking water</b>						
Unprotected	0.196	0.083	5.625	1	0.018*	1.217
Protected(ref.)						
<b>Constant</b>	-1.987	0.384	6.623	1	0.0100*	0.373

\*Significant (p<0.05)

### 4.3 Determinants of Stunting in Children: A Multilevel Logistic Regression

#### Analysis

In the multilevel analysis, a two-level structure is used with regions as the second-level unit and children as the first-level units. This is basically with the expectation that there would be a difference in the nutritional status of children among the regions. The preliminary analysis using logistic regression in the previous section also revealed such differences. That is, the nesting structure is children within regions that resulted in a set of 11 regions with a total of 3095 children. As can be seen in Table 4.1, the percentage of stunted children varies between 20.5 percent in Addis Ababa and 58.5 percent in Amhara region.

A chi-square test statistic given in equation (3.7) was applied to assess heterogeneity in the proportion of stunted children among the 11 regions. The test yields  $X^2=95.5934$ ,  $d.f.=10$ ,  $P<0.01$ . Thus, there is evidence for heterogeneity among the regions with respect to stunting in children. Furthermore, the overall stunting in children at national level estimated to be 45.2 percent with standard error of 0.0887 which is calculated from equation (3.6)

The results presented in the subsequent sections are carried out using a student-version software LISREL for window. The program is restricted to analyze few number of explanatory variables. As a result, only five explanatory variables were considered i.e. employment status of mother, household economic status, preceding birth interval, age of child and source of drinking water.

#### 4.3.1 Empty Model for Stunting in Children

The empty model contains no explanatory variables and it can be considered as a parametric version of assessing heterogeneity among regions with respect to nutritional status of children. Fitting the empty model discussed in section 3.3.2.3 (i) with normally distributed log-odds yields the results presented in Table 4.5. The first column shows estimates of the parameters of the empty model. From the fixed part of the model, (i.e. intercept only), the rest clearly show that the model is statistically significant.

Table 4.5 Estimates for empty model

Fixed Part	Coefficient	S.E.	Z-value	P-value
$\beta_0 = \text{Intercept}$	-0.3578	0.0366	-9.7838	0.0000*
Random Part	Variance Component	S.E.	Z-value	P-value
<b>Level-two variance:</b>				
$\sigma_0^2 = \text{var}(U_{0j})$	0.1661	0.054	3.0741	0.0021*
<b>Deviance-based chi-square</b>	96.8476			0.000*

\* Significant ( $p < 0.01$ )

The estimated average log-odds is -0.3578 as shown in Table 4.5 above, which corresponds (according to equation (3.11)) to an estimated proportion of overall stunting at national level to be  $\pi_0 = 0.422$ . The variance approximation formula (3.12) yields  $\text{var}(P_j) \approx 0.0097$ , not too far from the non-parametric estimate calculated from (3.6), which is 0.00788. The difference between these values is caused by the fact that formula (3.6), is only an approximation and that the estimation methods are different. The variance of the empty model is significant which indicates that there is regional difference in the nutritional status of children. Table 4.5, provides a deviance based chi-square test for assessing the goodness of fit of the fitted empty model. The test indicates that the fitted model is good.

#### 4.3.2 Determinants of Stunting using Random Intercept Model and fixed Explanatory variables

In order to identify the effect of some selected explanatory variables a multilevel logistic regression model with random intercept and fixed explanatory variables was estimated with the help of LISREL software. The variables considered were employment status of mother (0 for employed, 1 for unemployed), household economic status (0 for poor, 1 for medium or higher), preceding birth interval (0 for <24months, 1 for 24 and more

months), age of child (0 for <24 months and 1 for 24-59 months), and source of drinking water (0 for unprotected, 1 for protected). The results are presented in Table 4.6. The deviance based chi-square test for significance of random effects ( $X^2=71.4801$ ,  $df = 1$ ,  $P<0.05$ ) indicates that the random intercept model with the fixed explanatory variables is found to be a better fit as compared to the empty model discussed in section 4.3.

As can be seen from Table 4.6, the analysis of multilevel logistic regression revealed that nutritional status of children varied among regions. In addition, employment status of mother, household economic status, preceding birth interval, age of child and source of drinking water were also found to be significant determinants of variation in stunting among the regions. As regard to regional difference, the nutritional status of children, at the level-two variance of the random intercept ( $\sigma_0^2$ ) was found to be significant, which imply regional difference in the nutritional status of children (Table 4.6).

The first column of Table 4.6 reports estimates derived from random intercept with fixed explanatory variables model. From the fixed part of the model, the results clearly show the relationship between nutritional status of children and household economic status, employment status of mother, preceding birth interval, age of child and source of drinking water. In general, children of employed mothers are more stunted than that of unemployed mothers, children from poor socioeconomic households are also more stunted than medium or high socioeconomic status households, and the rate of stunting decreases as the preceding birth interval increases.

Table 4.6 Results in Fixed and Random Intercept Model

Covariates	Estimate	S.E.	Z-value	P-value
<b>Intercept</b>	0.4269	0.0854	4.9985	0.0000*
<b>Employment status of mother</b>				
Employed (Ref.)				
Unemployed	-0.1990	0.0812	-2.4499	0.0143*
<b>Household Economic Status</b>				
Poor	1.0154	0.2222	4.5691	0.0000*
Medium or Higher (Ref.)				
<b>Preceding birth interval</b>				
<24 months	0.2967	0.0759	3.9066	0.0001*
24 and more months (Ref.)				
<b>Age of child</b>				
<24 months	-0.6036	0.0780	-7.7434	0.0000*
24-59 months (Ref.)				
<b>Source of drinking water</b>				
Unprotected	0.2691	0.0762	3.5335	0.0004*
Protected (Ref.)				
<b>Random Part</b>	<b>Estimate</b>	<b>S.E.</b>	<b>Z-value</b>	<b>P-value</b>
<b>Random Intercept:</b>				
$\sigma_0^2 = \text{var}(U_{0j})$ intercept variance	0.0996	0.0337	2.9564	0.0031*
<b>Deviance-based chi-square</b>	71.4801			0.0000*

\* Significant (P<0.05)

#### 4.3.1 Determinants of Stunting using Random Coefficient Model

The random coefficient model is useful because it shows how much variability exists at each level. Results of Table 4.7 are obtained by including level-2 random coefficients to represent employment status of mother ( $X_1$ ), household economic status ( $X_2$ ), preceding birth interval ( $X_3$ ), age of child ( $X_4$ ) and source of drinking water ( $X_5$ ). The table includes fixed effect coefficients and an overall (level-2) or regional variance constant term ( $\sigma_0^2$ ) together with variance and covariance terms representing the random effects of employment status of mother, household economic status preceding birth interval, age of child and source of water and their interactions. The significance of these terms is indicated in the table 4.7. According to the overall region variance constant term, variance for employment status of mother, variance for age of child and variance

for source of drinking water are found significant. Besides, employment status of mother by household economic status covariance term is significant. Similarly, the fixed effects of employment status of mother, household economic status, preceding birth interval, age of child and source of drinking water are found significant. Accordingly, the results from the multilevel analysis show that employment status of mother, household economic status, preceding birth interval and age of child and source of drinking water are found to contribute in explaining the variation of stunting among the regions.

Table 4.7 Results for Fixed and Random Effects of Random Coefficient Model

Fixed Part	Estimate	S.E.	Z-value	P-value
<b>Intercept (<math>X_0</math>)</b>	0.3037	0.0855	3.5514	0.0004*
<b>Employment status of mother (<math>X_1</math>)</b>				
Employment	-0.2849	0.0819	-3.4827	0.0034*
Unemployed (Ref.)				
<b>Household Economic Status (<math>X_2</math>)</b>				
Poor	1.0423	0.2260	4.6130	0.0000*
Medium or Higher (Ref.)				
<b>Preceding birth interval (<math>X_3</math>)</b>				
<24 months	0.3008	0.0764	3.9370	0.0001*
24 and more months (Ref.)				
<b>Age of child (<math>X_4</math>)</b>				
<24 months	-0.5425	0.0783	-6.9317	0.0000*
24 and more months (Ref.)				
<b>Source of drinking water (<math>X_5</math>)</b>				
Unprotected	0.3984	0.0765	5.2087	0.0000*
Protected (Ref.)				
<b>Random Part</b>	<b>Estimate</b>	<b>S.E.</b>	<b>Z-value</b>	<b>P-value</b>
<b>Random Coefficient:</b>				
<b>Level-2 variance and covariance</b>				
$\sigma_0^2 = \text{var}(U_{0j})$	0.0117	0.0047	2.4758	0.014*
$\sigma_1^2 = \text{var}(U_{1j})$	0.0923	0.0375	2.4639	0.0137*
$\sigma_2^2 = \text{var}(U_{2j})$	0.1943	0.0994	1.9551	0.0506
$\sigma_3^2 = \text{var}(U_{3j})$	0.0062	0.0071	0.8714	0.3835
$\sigma_4^2 = \text{var}(U_{4j})$	0.0709	0.0298	2.3806	0.0173*
$\sigma_5^2 = \text{var}(U_{5j})$	0.0978	0.0344	2.8401	0.0045*
$\sigma_{01} = \text{cov}(U_{0j}, U_{1j})$	0.0067	0.0111	0.6061	0.5444

$\sigma_{02} = \text{cov}(U_{0j}, U_{2j})$	-0.0033	0.0207	-0.1576	0.8748
$\sigma_{03} = \text{cov}(U_{0j}, U_{3j})$	-0.0064	0.0058	-1.1058	0.2688
$\sigma_{04} = \text{cov}(U_{0j}, U_{4j})$	-0.0107	0.0107	-1.0044	0.3152
$\sigma_{05} = \text{cov}(U_{0j}, U_{5j})$	0.0208	0.0107	1.7438	0.0812
$\sigma_{12} = \text{cov}(U_{1j}, U_{2j})$	0.1167	0.0527	2.2125	0.0269*
$\sigma_{13} = \text{cov}(U_{1j}, U_{3j})$	-0.0118	0.0093	-1.2743	0.2026
$\sigma_{14} = \text{cov}(U_{1j}, U_{4j})$	-0.0418	0.0262	-1.5962	0.1105
$\sigma_{15} = \text{cov}(U_{1j}, U_{5j})$	0.0315	0.0264	1.1925	0.2330
$\sigma_{23} = \text{cov}(U_{2j}, U_{3j})$	-0.0042	0.0199	-0.2132	0.8312
$\sigma_{24} = \text{cov}(U_{2j}, U_{4j})$	-0.0440	0.0383	-1.1493	0.2504
$\sigma_{25} = \text{cov}(U_{2j}, U_{5j})$	0.0351	0.0398	0.8840	0.3767
$\sigma_{34} = \text{cov}(U_{3j}, U_{4j})$	0.0129	0.0085	1.5141	0.1300
$\sigma_{35} = \text{cov}(U_{3j}, U_{5j})$	-0.0069	0.0082	-0.8413	0.4002
$\sigma_{45} = \text{cov}(U_{4j}, U_{5j})$	0.0136	0.0225	0.6041	0.5458
Deviance-based chi-square	129.7272			0.0000*

\* Significant (P<0.05)

Ref. =Reference category

### Level-2 Covariance Matrix of the Random Coefficient

	$X_0$	$X_1$	$X_2$	$X_3$	$X_4$	$X_5$
$X_0$	0.011669					
$X_1$	0.006737	0.092284				
$X_2$	-0.003260	0.116707	0.194347			
$X_3$	-0.006436	-0.011808	-0.004240	0.006197		
$X_4$	-0.010707	-0.041768	-0.043978	0.012862	0.070872	
$X_5$	0.020758	0.031520	0.035143	-0.006935	0.013603	0.097782

### Level-2 Correlation Matrix of the Random Coefficient

	$X_0$	$X_1$	$X_2$	$X_3$	$X_4$	$X_5$
$X_0$	1.000000					
$X_1$	0.205293	1.000000				
$X_2$	-0.068464	0.871456	1.000000			
$X_3$	-0.756785	-0.493760	-0.122186	1.000000		

$X_4$	-0.372320	-0.516471	-0.374721	0.613729	1.000000	
$X_5$	0.614531	0.331812	0.254932	-0.281702	0.163409	1.000000

The deviance based chi-square test for significance of random effects ( $X^2=129.7272$ ,  $df = 21$ ) indicates that the random coefficient is statistically significant. In comparison to the model with random intercept and fixed explanatory variables, the model with random intercept and random coefficients to the explanatory variables found to be the 'best' fit in explaining regional differences in the nutritional status of children.

The intercept variance,  $\sigma_0^2$ , represents the amount of variation in stunting across regions within children whilst controlling for differences in employment status of mother, household economic status, preceding birth interval, age of child and source of drinking water. The fixed effect of Employment status of mother, household economic status, preceding birth interval, age of child and source of drinking water all which is consistent with the logistic regression analysis is significant across the regions. The variance of mothers' employment status in Table 4.7 was also statistically significant. Besides, the slope variance was also significant which showed high variation across regions in terms of mothers' employment status, age of child and source of drinking water.

On the other hand, preceding birth interval is another important variable which affects the nutritional status of children. When we consider employment status of mother to household economic status as random variable among regions, the covariance is significant which implies there were differences across regions (Table 4.7).

We note that the student version of the software LISREL does not provide model diagnostic tests. We only checked a goodness of fit by using deviance based chi-squared test.

In general, the results of the multilevel logistic regression suggest that there exist difference in the nutritional status of children among the regions in Ethiopia and the effect of employment status of mothers, age of the child and source of drinking water on children nutritional status differs from region to region. As a result, the random

coefficient model analysis generates separate estimates of logistic regressions for each region (Table 4.8).

**Table 4.8 Parameter estimates among the Regions**

Region	Coefficients						
		$X_0$	$X_1$	$X_2$	$X_3$	$X_4$	$X_5$
Tigray	Estimate	-0.0675584	-0.1070527	-0.1727483	0.0262544	0.1305267	-0.2129384
	S.E.	0.0063652	0.0254688	0.0849912	0.0037023	0.0220822	0.0118794
	Z-value	-10.61371*	-8.406576*	-2.0325434*	7.0913756*	5.9109464*	-17.925013*
Afar	Estimate	0.0508957	0.2157036	0.2543673	-0.0382311	-0.0622531	0.2178513
	S.E.	0.0080900	0.0634555	0.1417847	0.0048179	0.0318477	0.0347894
	Z-value	6.2911867*	3.3992892*	1.7940391*	-7.9352207*	-1.954713*	6.262002*
Amhara	Estimate	-0.1748575	-0.3998478	-0.3988328	0.0965054	0.0785515	-0.6307808
	S.E.	0.0059294	0.0242050	0.0822052	0.0036844	0.0205285	0.0113755
	Z-value	-29.489915*	-16.51922*	-4.851674*	26.192976*	3.826461*	-55.45082*
Oromiya	Estimate	0.0610619	-0.2870238	-0.4198115	-0.0025900	-0.0036993	0.0158047
	S.E.	0.0050858	0.0180762	0.0634107	0.0033148	0.0164252	0.0079239
	Z-value	12.006351*	-15.8785*	-6.6205*	-0.78134	-0.2251	1.99456*
Somali	Estimate	-0.0307870	0.0820518	0.1405584	0.0037685	-0.0579545	-0.0912367
	S.E.	0.0079345	0.0528457	0.1309577	0.0045503	0.0287913	0.0319936
	Z-value	-3.880144*	1.5526675	1.0733114	0.828187	-2.012917*	-2.85171*
Ben-Gumz	Estimate	0.0504289	0.1556716	0.1278196	-0.0445071	-0.0832061	0.1199269
	S.E.	0.0069962	0.0329345	0.1009690	0.0040976	0.0287483	0.0164201
	Z-value	7.2080415*	4.726703*	1.265929	-10.861748*	-2.894296*	7.30366*
SNNP	Estimate	0.0137952	0.3766836	0.4658482	-0.0770172	-0.5375113	-0.2535587
	S.E.	0.0054114	0.0242298	0.0800549	0.0034737	0.0179151	0.0091750
	Z-value	2.549284*	15.54629*	5.819109*	-22.171517*	-30.00325*	-27.6358*
Gambela	Estimate	0.0343153	-0.0020521	0.0193549	0.0210875	0.3126633	0.4104556
	S.E.	0.0085670	0.0524640	0.1293249	0.0049190	0.0371609	0.0315247
	Z-value	4.005521*	-0.0391144	0.14966104	4.2869485*	8.413770*	13.02012*
Harari	Estimate	0.0358633	-0.2887000	-0.4894562	-0.0020985	0.0819459	-0.0260344
	S.E.	0.0074869	0.0327386	0.0715933	0.0046281	0.0375161	0.0182857
	Z-value	4.790140111*	-8.818336*	-6.8366201*	-0.453425	2.1842862*	-1.4237574
Dire Dawa	Estimate	-0.0112398	0.1317532	0.2822165	0.0249532	0.1094246	0.2061729
	S.E.	0.0081268	0.0499828	0.1120075	0.0050121	0.0425095	0.0224231
	Z-value	-1.3830536	2.6359708*	2.5196215*	4.97859181*	2.5741211*	9.194665*
Addis Ababa	Estimate	0.0380825	0.1228125	0.1906840	-0.0081251	0.0315125	0.2443376
	S.E.	0.0091856	0.0498246	0.1016040	0.0054332	0.0523335	0.0305185
	Z-value	4.14589139*	2.464896858*	1.87673713	-1.4954538	0.6021477	8.0062126*

\*significant (p<0.05)

As can be seen from Table 4.8, the explanatory variables considered are not found statistically significant in all the regions. For example, in Tigray, Afar and Amhara all

variables are found significant whereas in Addis Ababa only employment status and source of drinking water found significant.

## CHAPTER FIVE

### DISCUSSION, CONCLUSION AND RECOMMENDATION

#### 5.1 Discussion

This study was designed to identify some of the determinants of the nutritional status of children based on EDHS 2005 data. Accordingly, multiple logistic regression and multilevel logistic regression techniques were comprised. The multiple logistic regression has been applied separately on rural, urban and national level (combined urban and rural) data. The results obtained are discussed as follows.

A finding that is consistent with past studies is that stunting is more prevalent in rural children than their urban counterpart. This may be related to access to social services (like education and health) and the availability of adequate dietary intake in the urban parts of Ethiopia. In general, people living in urban areas have better health and lower death rates than rural residents, even though the urban poor often live in unsanitary and crowded conditions (UN, 1985). Compared with rural children, urban children have better access to medical services and are more easily reached by educational campaigns. Different researches also confirmed that in developing countries like Ethiopia, food availability is in a devastating condition and the extent is high in rural parts of Ethiopia than in urban parts of Ethiopia (Summerfelt and Stewart, 1994).

Concerning the regional variation in children's nutritional status, the results from both rural and urban parts of Ethiopia confirmed that children who live in Amhara and SNNP are at a higher risk of stunting than children who live in other regions. Moreover the Urban Model in Table 4.2 and national level Model in Table 4.4 also confirmed that besides children in Amhara and SNNP, children in Tigray, Oromiya and Harari are at a higher risk of stunting than children who live in Addis Ababa. The observed higher risk of malnutrition in Tigray, Amhara and SNNP regions may be attributed to differences in cultural and dietary practices (Woldemariam and Timotiws, 2002).

Age of child is also found to be significantly related to stunting. The descriptive analysis in Table 4.1 suggested that as children grow older, their nutrition status diminishes accordingly. This could be because of breastfeeding in the early stages of child

development (0 to 24 months) and also due to the care that parents give to older children that may decline especially if there are younger children in the family.

Another most important determinant factor which affects nutritional status of children in Ethiopia is household economic status. Children in the poor household economic status are found to be at a higher risk of under nutrition than children in medium or higher household economic status. This finding seemed to be consistent with other studies (Woldemariam and Timotiws, 2002). They indicated that household economic status was directly associated with household food security which is a precondition for children to get access to adequate dietary intake and improved nutritional status.

Preceding birth interval is also important demographic variable that affects nutritional status of children. The significant and higher risk of stunting among children of lower preceding birth interval could be due to uninterrupted pregnancy and breastfeeding, since this drains women's nutritional resources (Sommerfelt et al., 1994). Close-spacing may also have a health effect on the previous child who may be prematurely weaned if the mother becomes pregnant too early again. In this study, rural children were found to be the most affected in their nutritional status due to close spacing and this may be due to the low contraceptive prevalence rate in the rural areas.

Regarding to women's employment status both the multiple logistic regression results confirm that, unemployment status of women is associated with better nutritional status among children in Ethiopia and between regions. According to the study findings, mother's is not a significant risk factor of malnutrition status. This may be because of the fact that time allocated to earning income may be at the expense of time spent in feeding and caring for children (Sommerfelt et al., 1994). Moreover, since the majority of mothers in developing countries like Ethiopia work in the informal sectors and in lower status jobs, the amount of income for these mothers is low and would have a negligible impact on the nutritional status of children of employed mothers.

Another important statistical analysis used in this study is multilevel logistic regression which is an example of generalized hierarchal linear model. In the multilevel analysis children are considered as nested within the various regions in Ethiopia. Three multilevel

models: empty model, random intercept and slope or random coefficient model were applied in order to explain regional differences in the nutritional status of children. The results obtained are discussed briefly in the following subsequent sections.

Before the analysis of data using the multilevel approach, first the heterogeneity of the nutritional status of children with regard to regions was checked. The nonparametric approach based on the chi-square test and the parametric approach based on the empty model suggests that nutritional status of children differs among regions. Such heterogeneity is a requirement in the multilevel analysis.

In addition, a model without explanatory variables, two other models were run using multilevel logistic regression for the national sample as a whole. In general, the fixed part of the effects of explanatory variables included in the models have somewhat similar interpretation as that of the multiple logistic regression discussed above for the national level data. Whereas the random parts of the intercept and explanatory variables provided additional information.

In both models the overall variance constant term found to be statistically significant which may again imply the differences in the nutritional status of children. Among the five variables considered due to the restriction in the software used, the effect of the random part of employment status of mothers, age of child and source of drinking water on nutritional status of children differs across regions. Similarly, the interaction of the random parts of employment status of mothers and household economic status provided significant effect on nutritional status across regions.

## 5.2 CONCLUSIONS AND RECOMMENDATION

The study revealed that socio-economic and demographic variables have a significant effect in the nutritional status among children in Ethiopia. Place of residence, region of residence, age of child, employment status, economic status and birth interval are the most important ones.

Child's age has shown a strong positive and significant association with its stunting. Thus, efforts should be made to communicate through different programs, such as health and nutritional education, the importance of feeding breast milk exclusively up to 4-6 months and thereafter introducing other supplementary foods which are rich in their nutrients that should form the part of the nutritional policy.

Although there is region wise disparity in children's nutritional status, in all regions it is observed that children living in the rural parts of the country are at higher risk stunting. Therefore, it is useful to strengthen food security programs in all these risked areas to directly address not only the food insecurity, but also malnutrition targeting of the poor and vulnerable communities and households found in rural parts of the country.

The result also suggested that agricultural workers are the most affected groups of the population by stunting. This is related to low productivity of agricultural products which in turn is related with food insecurity and low access to daily dietary intake. In order to strengthen the link between nutrition and agriculture the government develop a policy so as sufficient food is available to all people at all times at a price they can afford.

The study revealed that children of the poor (low economic status) households showed the highest rates of stunting. This would be due to the manifestation of the food insecurity observed in these households that negatively affected the nutritional status of children, in particular, and the other household members in general. Therefore, measures should take including action to support the poor, and to bring about rapid economic growth the risked (stunting) areas in particular and at the national level in general. To this effect, it is important to develop community-based interventions giving priority to poor households as a short-term solution and implementation of poverty reduction strategies and programs as a long-term solution to the problem.

Close-spacing of births, i.e. having a preceding birth interval of less than 24 months showed a significant nutritional deficit in the younger children, particularly in the rural areas. This is associated with risk factors such as mothers' inadequate capacity for caring for her children. Also, the mother herself biologically depleted from too frequent births, and this could also negatively affect the nutritional status of the newborn baby. Therefore, access to family planning services for prolonging the intervals between births could benefit the youngest child and the mother. Thus, access to family planning, could be an important element of strategy to improve child nutrition.

Since the study has shown that diarrhea and source of drinking water aggravate the problem related to children nutritional status efforts should be made in improving accessibility of drinking water, environmental sanitation and personal hygiene to prevent exposure to diarrhea and encouraging breast feeding.

The study results showed that regions like Tigray, Amhara and SNNP have high rate of stunting in their children. In general, nutritional status of children varies among the regions. This may be associated with food security programs, unevenly distributed and limited healthcare facilities, cultural and dietary practices, inequality in the distribution of services and resources. Therefore, primary health care and nutrition programs should be designed and implemented which would fit to the overall features of the regions to safeguard children for nutritional deficiency at each region.

## REFERENCES

- Abbi, R., P. Christian, S. Gujral, and Gopaldas, T. (1991). *The impact of maternal work on the nutrition and health status of children*. Food and Nutrition Bulletin 13(1):20-24.
- Abey Koon (1995). *Sex preference in South Asia: Srilanka and outliers*. Asia-Pacific Population Journal.
- Administration Committee on Coordination–Sub-Committee on Nutrition (ACC/SCN) (2000). *Fourth Report on the World Nutrition situation: ACC/SCN in collaboration with International Food Policy Research Institution, Geneva*.
- Agresti, A. (1990). *Categorical Data Analysis*. New York: Wiley.
- Agresti, A. (1996). *An Introduction to Categorical data Analysis*. Johan Wiley and Sons, Inc., New York.
- Aschalew Gemechu (2000). *Determinants of the nutritional status of children in Amhara Region: the case of Misrake Gojjam and Semen Wollo Zones*. MSc. Thesis AAU
- Berg, A. (1981). *Malnourished people, a policy view: Poverty and Basic needs serious*. WB, Washington DC.
- Chaudhury R.H (1988). *Adequacy of Child Dietary Intake Relative to the other Family Members*. Food and Nutrition Bulletin; 10(1):52-55
- Commenges, D. and Jacqmin, H. (1994). *The intraclass correlation coefficient: distribution free definition and test*. Biometrics, 50, 517-526.
- Dibley et al. (1987). *Development of Normalized Curve Interpretation of Z-score anthropometric indicators derived from the international growth reference*. American Journal of Clinical Nutritional; 46(5):749-62
- EDHS (2001). *Ethiopian Demographic and Health Survey*. Addis Ababa
- EDHS (2006). *Ethiopian Demographic and Health Survey*. Addis Ababa

- Engle, P.L., and P. Menon (1996). Urbanization and Care giving: Evidence from South and Eastern Africa. California: Department of Psychology and Human development, California Polytechnic, Stat. University: 4-24.
- Genebo, T., W. Girma, J. Hadir, and T. Demmissie (1999). *The association of children's nutritional status to maternal education in Ziggaboto, Guragie Zone South Ethiopia*. Ethiopian Journal of Health Development 13(1):55-61.
- Gugsa Yimer. (1998). *Risk factors for the malnutrition of children nutritional status in Southern Ethiopia, DTRC/IDR*. MSc. Thesis, Addis Ababa University, 1999
- Gugsa Yimer (2000). *Malnutrition among children in southern Ethiopia: Levels and risk factors*. Ethiopian Journal of Health Development 14(3):283-292.
- Han-Am and Sleigh-A (1995). *Persistent diarrhea in Children admitted to Port Moore by General Hospital*. P.N.G. Med. Journal; 38(4): 272-77.
- Jelliff, D.B (1982). *Child Nutrition in developing countries*. U.S. Dep. of state Report: Agency for international Dev. of the war on hunger, Washington Dc.
- Kogi-Makua W. (1996). *Risk indicators of Nutritional status of households of Kenyan Semi-Arid Population*, East African Med. J.
- Leslie, J. (1988). *Women's work and child nutrition in the third world*. World Development 16(1).
- Maurie, C.Y et al. (1992). *Some determinants of nutritional status of one-to four year old children in low income urban areas in Tanzania*, Journal of Tropical Pediatrics.
- McCullagh, P. and Nelder, J.A. (1989). *Generalized Linear Models*. 2<sup>nd</sup> edn. London: Chapman and Hall.
- Melaku Eshetu (1997). *Correlates of nutritional status of under-five children in southern Ethiopia*. Ethiopia Journal of Development Research vol.20, No.1, Addis Ababa

- Micheal Adam (2000). *The relationship between nutritional status of children and KAP of mothers' feeding their children in a Rural Community: Hawa-Michael, Bugna Woreda, and Southern Wollo*. MSc. Thesis, AAU.
- Pelletier, D.L. (1991). *Relationships between Child Anthropometry and Mortality in Developing Countries: Implications for Policy, Programmes, and further Research*, Monograph 12. September, 1991.
- Popkin, B.M. (1980). *Time allocation of the mother and child nutrition*. Ecology of Food and Nutrition 9:1-14.
- Snijders Tom A.B. and Roel J. Bosker (1999). *An introduction to basic and advanced multilevel modeling*. Department of Statistics, University of Poone, Pune 7.
- Sommerfelt and Stewart (1994). *Children's Nutritional Status*. DHS Comparative Studies No. 12 Calverton, Maryland; Macro international Demographic and Health Surveys (DHS).
- Sommerfelt, A. Elizabeth, and S. Kathryn (1994). *Children's nutritional status*. DHS Comparative Studies No. 12. Calverton, Maryland, USA: Macro International Inc.
- Strauss, J. (1990). "Household, Communities, and Preschool Children's Nutritional Outcomes": Evidence from Rural Coted'Ivoire. Economic development and cultural change 38:231-261 traditional area of urban Izorin. East African Med. Journal, 73(5).
- United Nations (1985). *Population consensus at Cairo, Mexico City and Bucharest*. Analytical Report, New Work.
- United Nations Children's Fund (UNICEF) (1990). *Strategies of improving nutrition of children and women in developing countries*. New York: UNICEF.
- World Health Organization (1986). *Use and Interpretation and anthropometric indicators of nutritional status*. Bull. WHO.
- Woldemariam Girma and Timotiows Genbo (2002). *Determinants of the Nutritional Status of Mothers, and Children in Ethiopia*. Calverton, Maryland, USA: ORC Macro.

Zewditu, G., U. Kelbessa, G. Timotewos, and N. Ayele (2001). *Review the status of malnutrition and trend in Ethiopia*. Ethiopian Journal of Health and Development 15(2):55-74

Zlotkin, S.H. (1991). *Neonatal Nutrition, Nutritional Biochemistry and Metabolism with Clinical Applications*. Second edition. Prentice Hall International Inc.

# APPENDIX

## Logistic Regression Output using enter method

Variables in the Equation (Urban)

		B	S.E.	Wald	df	Sig.	Exp(B)
Step	REGION			31.311	10	.001	
1(a)	REGION(1)	1.840	.728	6.388	1	.011	6.299
	REGION(2)	-1.491	1.165	1.637	1	.201	.225
	REGION(3)	1.292	.636	4.127	1	.042	3.638
	REGION(4)	1.315	.593	4.914	1	.027	3.723
	REGION(5)	1.199	.620	3.748	1	.053	3.318
	REGION(6)	.732	.783	.874	1	.350	2.079
	REGION(7)	.069	.582	.014	1	.905	1.072
	REGION(8)	-2.451	1.169	4.393	1	.036	.086
	REGION(9)	1.495	.582	6.592	1	.010	4.460
	REGION(10)	-.196	.615	.101	1	.750	.822
	EDUCMOTH(1)	-.022	.394	.003	1	.955	.978
	EDUCPART(1)	.196	.404	.234	1	.629	1.216
	EMPOPART(1)	.923	.598	2.386	1	.122	2.518
	EMPLMOTH(1)	-.412	.331	1.553	1	.213	.662
	HE(1)	1.025	.416	6.059	1	.014	2.788
	SEXHH(1)	-.476	.381	1.561	1	.212	.621
	AGECHILD			9.693	5	.084	
	AGECHILD(1)	-2.594	1.121	5.360	1	.021	.075
	AGECHILD(2)	-1.145	.579	3.908	1	.048	.318
	AGECHILD(3)	-.040	.440	.008	1	.928	.961
	AGECHILD(4)	-.480	.451	1.132	1	.287	.619
	AGECHILD(5)	-.692	.475	2.119	1	.145	.501
	SEXCHILD(1)	-.371	.305	1.473	1	.225	.690
	BORD			8.269	3	.061	
	BORD(1)	.353	.527	.447	1	.504	1.423
	BORD(2)	1.073	.431	6.192	1	.053	2.923
	BORD(3)	1.041	.463	5.055	1	.025	2.832
	BIRTH			7.516	3	.057	
	BIRTH(1)	1.132	.465	5.929	1	.015	3.101
	BIRTH(2)	.563	.411	1.876	1	.171	1.756
	BIRTH(3)	-.015	.432	.001	1	.972	.985
	WATER(1)	-.857	.562	2.324	1	.127	.424
	TOILET(1)	.048	.432	.012	1	.912	1.049
	DIARRHEA(1)	.155	.486	.101	1	.750	1.167
	Constant	-2.470	.669	13.635	1	.000	.085

a Variable(s) entered on step 1: REGION, EDUCMOTH, EDUCPART, EMPOPART, EMLMOTH, HE, SEXHH, AGECHILD, SEXCHILD, BORD, BIRTH, WATER, TOILET, DIARRHEA

Variables in the Equation (Rural)

		B	S.E.	Wald	df	Sig.	Exp(B)
Step	REGION			51.714	9	.000	
1(a)	REGION(1)	.209	.271	.595	1	.440	1.233
	REGION(2)	.337	.301	1.254	1	.263	1.400
	REGION(3)	.838	.270	9.607	1	.002	2.311
	REGION(4)	.251	.260	.927	1	.336	1.285
	REGION(5)	.387	.300	1.662	1	.197	1.472
	REGION(6)	.071	.287	.061	1	.805	1.073
	REGION(7)	.784	.272	8.328	1	.004	2.190
	REGION(8)	-.151	.321	.220	1	.639	.860
	REGION(9)	.109	.312	.122	1	.726	1.115
	EDUCMOTH(1)	.144	.120	1.431	1	.232	1.155
	EDUCPART(1)	.106	.096	1.234	1	.267	1.112
	EMPOPART(1)	-.140	.178	.622	1	.430	.869
	EMPLMOTH(1)	-.214	.093	5.352	1	.021	.807
	HE(1)	.587	.467	1.578	1	.209	1.799
	SEXHH(1)	-.139	.128	1.165	1	.280	.871
	AGECHILD			166.965	5	.000	
	AGECHILD(1)	-2.468	.251	96.686	1	.000	.085
	AGECHILD(2)	-1.075	.162	43.931	1	.000	.341
	AGECHILD(3)	.115	.124	.865	1	.352	1.122
	AGECHILD(4)	.020	.123	.027	1	.871	1.020
	AGECHILD(5)	.167	.119	1.976	1	.160	1.182
	SEXCHILD(1)	-.125	.082	2.336	1	.126	.883
	BORD			5.725	3	.126	
	BORD(1)	-.254	.124	4.213	1	.040	.776
	BORD(2)	-.217	.107	4.094	1	.043	.805
	BORD(3)	-.119	.117	1.043	1	.307	.888
	BIRTH			8.278	3	.041	
	BIRTH(1)	.320	.134	5.677	1	.017	1.377
	BIRTH(2)	.190	.120	2.512	1	.113	1.210
	BIRTH(3)	.027	.130	.044	1	.833	1.028
	WATER(1)	.209	.086	5.964	1	.015	1.233
	TOILET(1)	.034	.107	.098	1	.754	1.034
	DIARRHEA(1)	.210	.106	3.910	1	.058	1.234
	Constant	-.881	.571	2.375	1	.123	.415

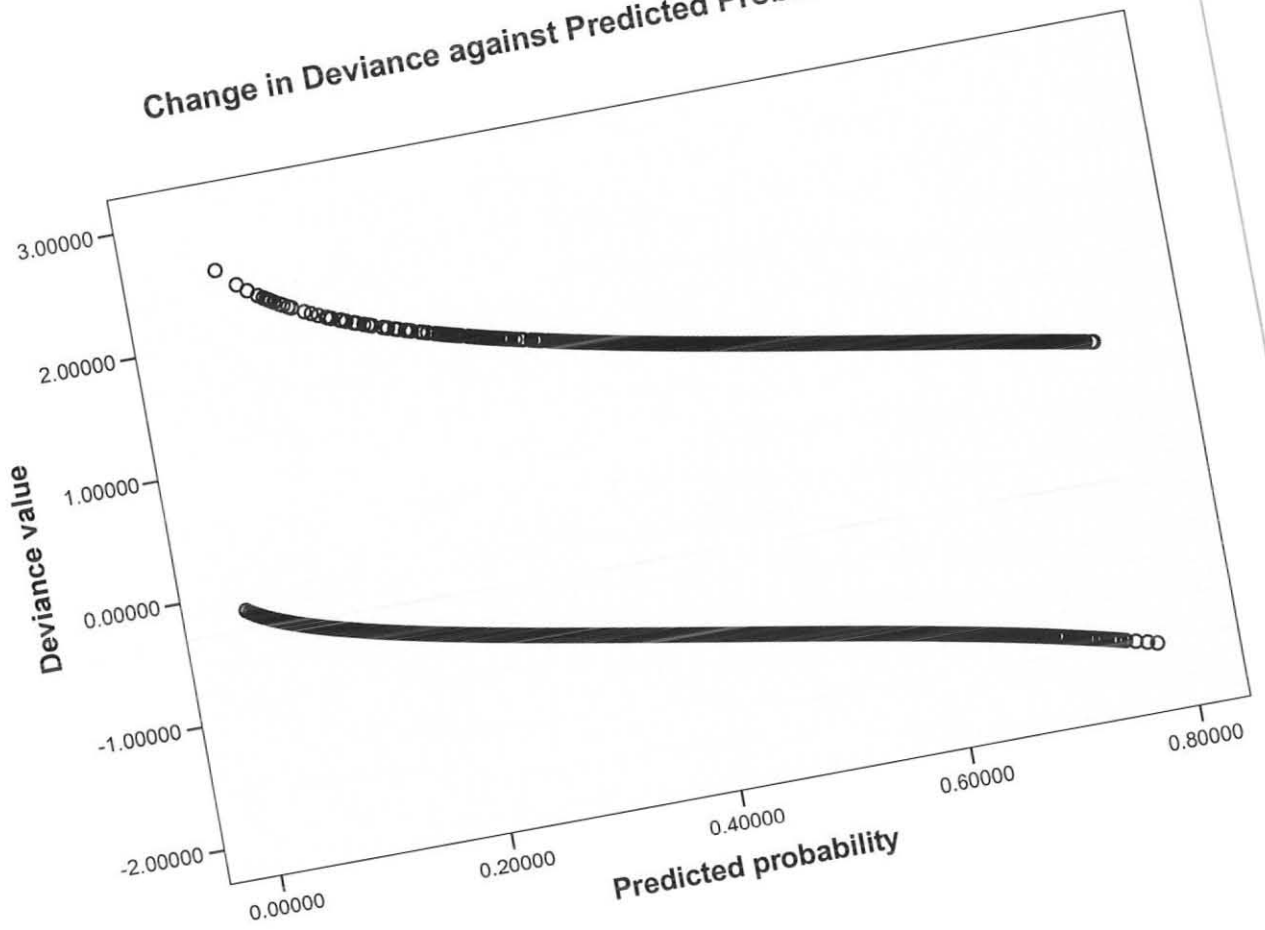
a Variable(s) entered on step 1: REGION, EDUCMOTH, EDUCPART, EMPOPART, EEMPLMOTH, HE, SEXHH, AGECHILD, SEXCHILD, BORD, BIRTH, WATER, TOILET, DIARRHEA.

Variables in the Equation (Total)

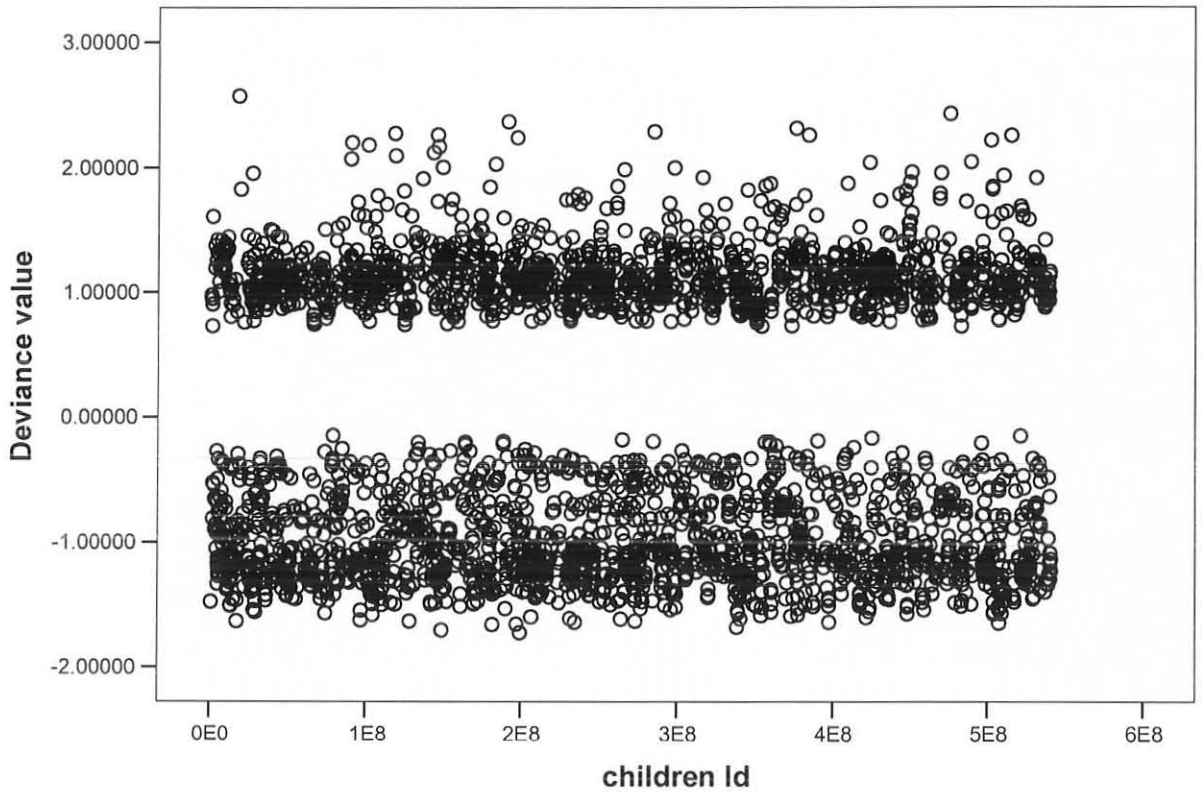
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1(a)	RESIDENCE(1)	.666	.213	9.777	1	.002	1.947
	REGION			61.904	10	.000	
	REGION(1)	.295	.323	.835	1	.361	1.343
	REGION(2)	.274	.343	.642	1	.423	1.316
	REGION(3)	.909	.320	8.068	1	.005	2.482
	REGION(4)	.312	.314	.988	1	.320	1.366
	REGION(5)	.484	.338	2.054	1	.152	1.623
	REGION(6)	.104	.333	.099	1	.754	1.110
	REGION(7)	.784	.317	6.121	1	.013	2.191
	REGION(8)	-.246	.354	.485	1	.486	.782
	REGION(9)	.298	.342	.763	1	.382	1.348
	REGION(10)	-.071	.357	.039	1	.844	.932
	EDUCMOTH(1)	.135	.113	1.431	1	.232	1.144
	EDUCPART(1)	.100	.092	1.181	1	.277	1.105
	EMPOPART(1)	-.117	.166	.494	1	.482	.890
	EMPLMOTH(1)	-.218	.088	6.198	1	.013	.804
	HE(1)	.569	.261	4.746	1	.029	1.766
	SEXHH(1)	-.145	.119	1.498	1	.221	.865
	AGECHILD			172.622	5	.000	
	AGECHILD(1)	-2.486	.244	103.692	1	.000	.083
	AGECHILD(2)	-1.071	.155	47.788	1	.000	.343
	AGECHILD(3)	.097	.118	.685	1	.408	1.102
	AGECHILD(4)	-.018	.117	.025	1	.875	.982
	AGECHILD(5)	.098	.114	.747	1	.387	1.103
	SEXCHILD(1)	-.154	.078	3.878	1	.049	.858
	BORD			4.354	3	.226	
	BORD(1)	-.231	.118	3.794	1	.051	.794
	BORD(2)	-.136	.102	1.788	1	.181	.873
	BORD(3)	-.057	.111	.266	1	.606	.944
	BIRTH			10.544	3	.014	
	BIRTH(1)	.337	.126	7.116	1	.008	1.401
	BIRTH(2)	.185	.113	2.696	1	.101	1.204
	BIRTH(3)	.010	.122	.007	1	.932	1.011
WATER(1)	.201	.084	5.815	1	.016	1.223	
TOILET(1)	.023	.102	.052	1	.819	1.024	
DIARRHEA(1)	.198	.102	3.751	1	.053	1.219	
Constant	-1.561	.342	20.869	1	.000	.210	

a Variable(s) entered on step 1: RESIDENCE, REGION, EDUCMOTH, EDUCPART, EMPOPART, EMPLMOTH, HE, SEXHH, AGECHILD, SEXCHILD, BORD, BIRTH, WATER, TOILET, DIARRHEA.

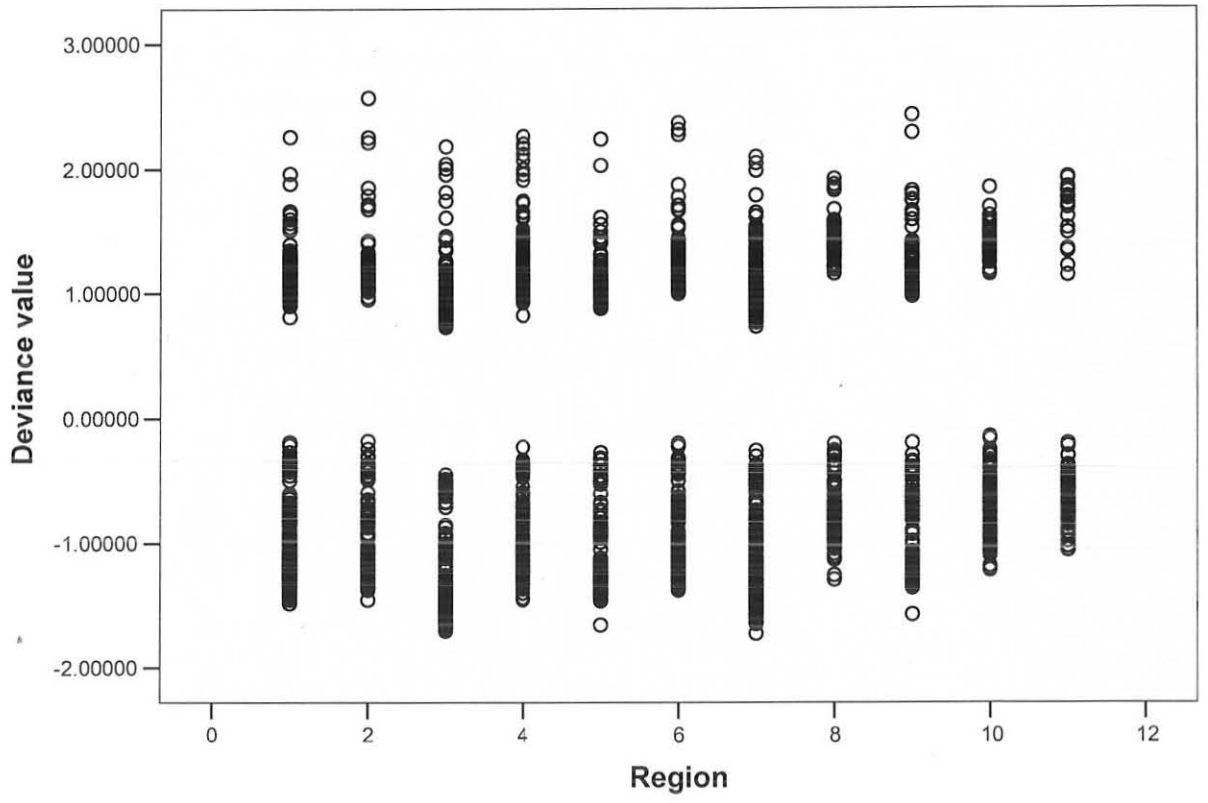
Change in Deviance against Predicted Probabilities



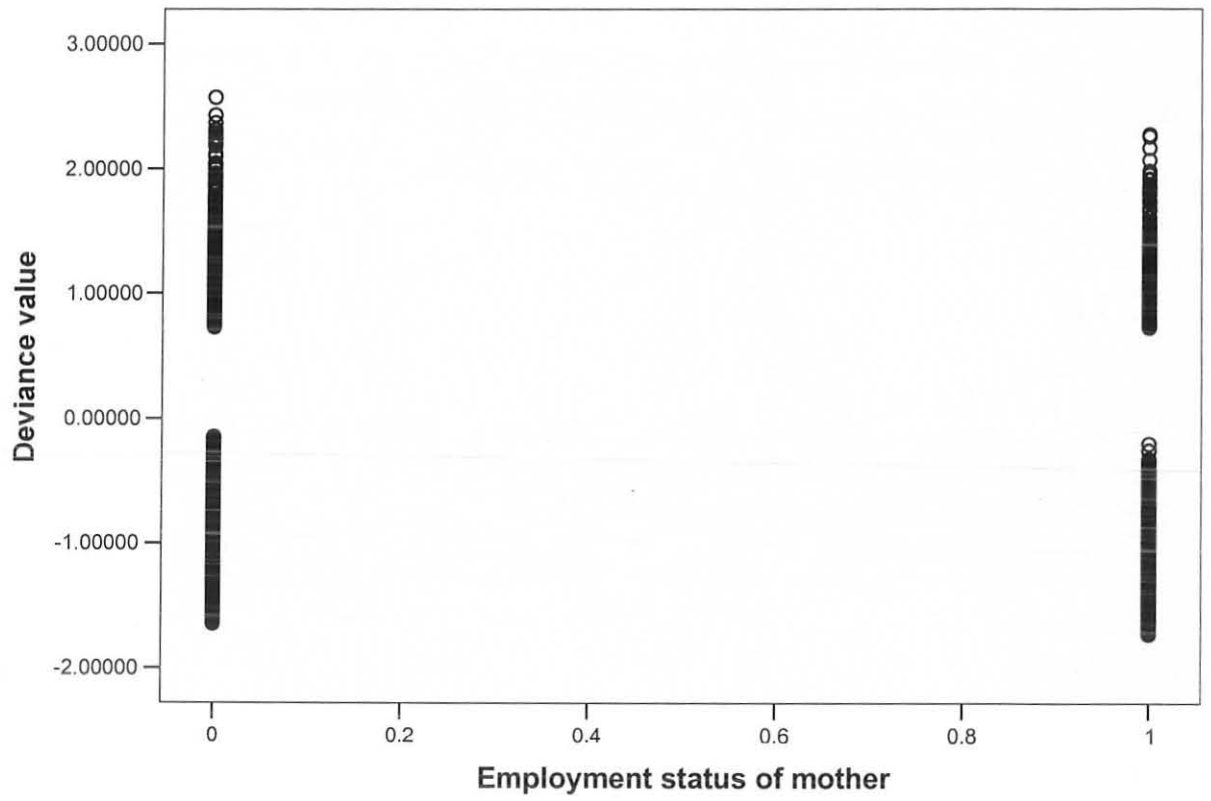
Deviance value against Childrens Id



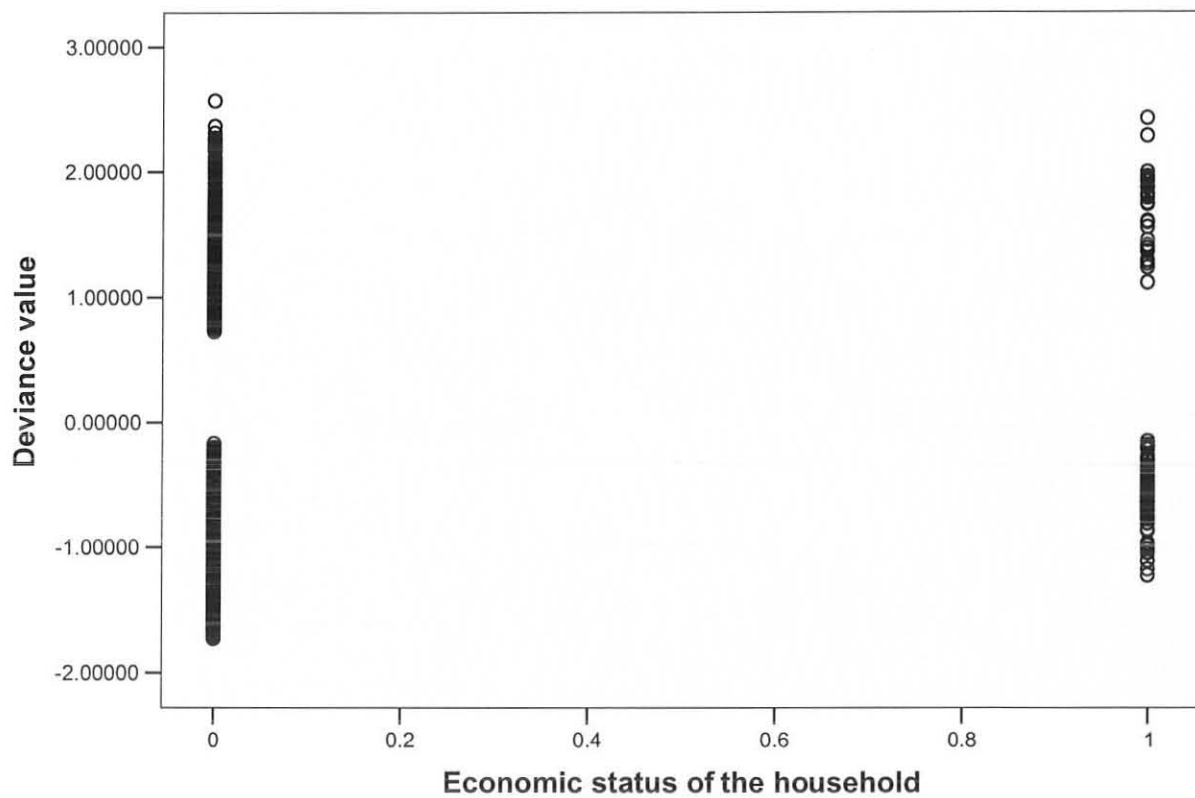
Deviance value against Region



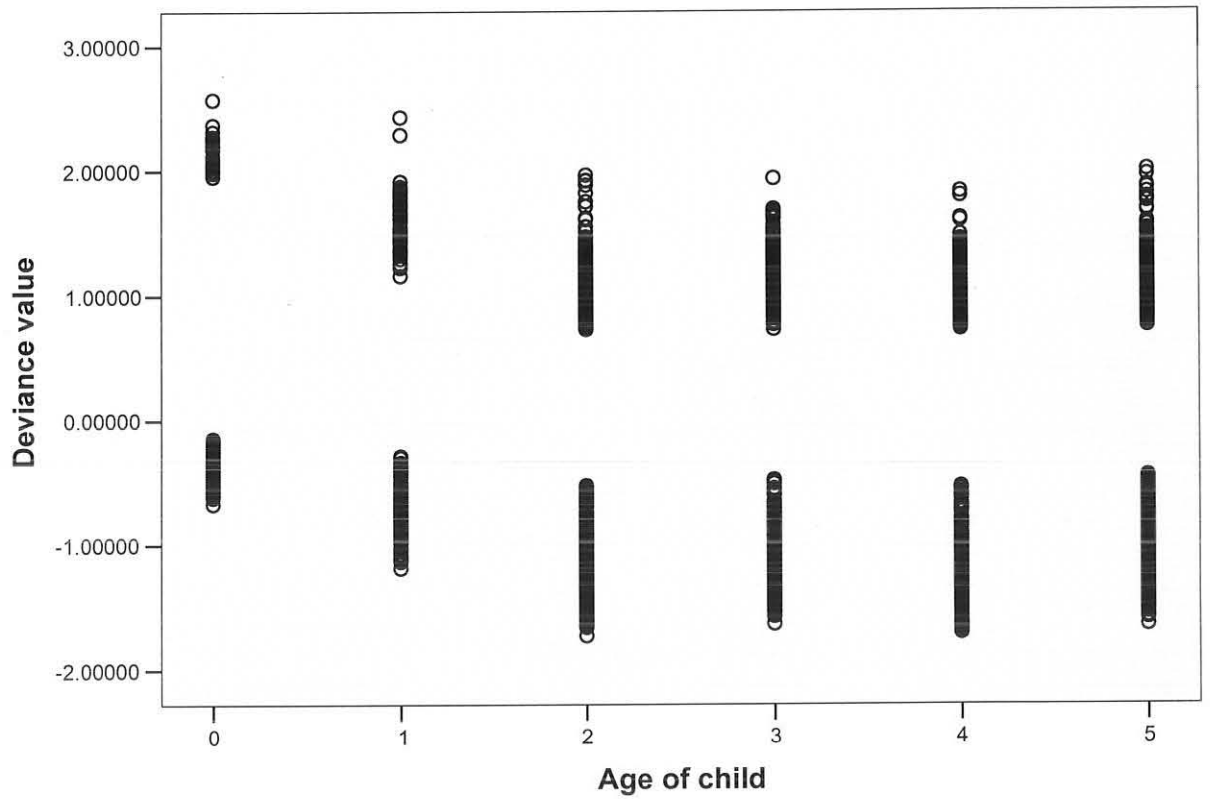
Deviance value against Employment status of mother



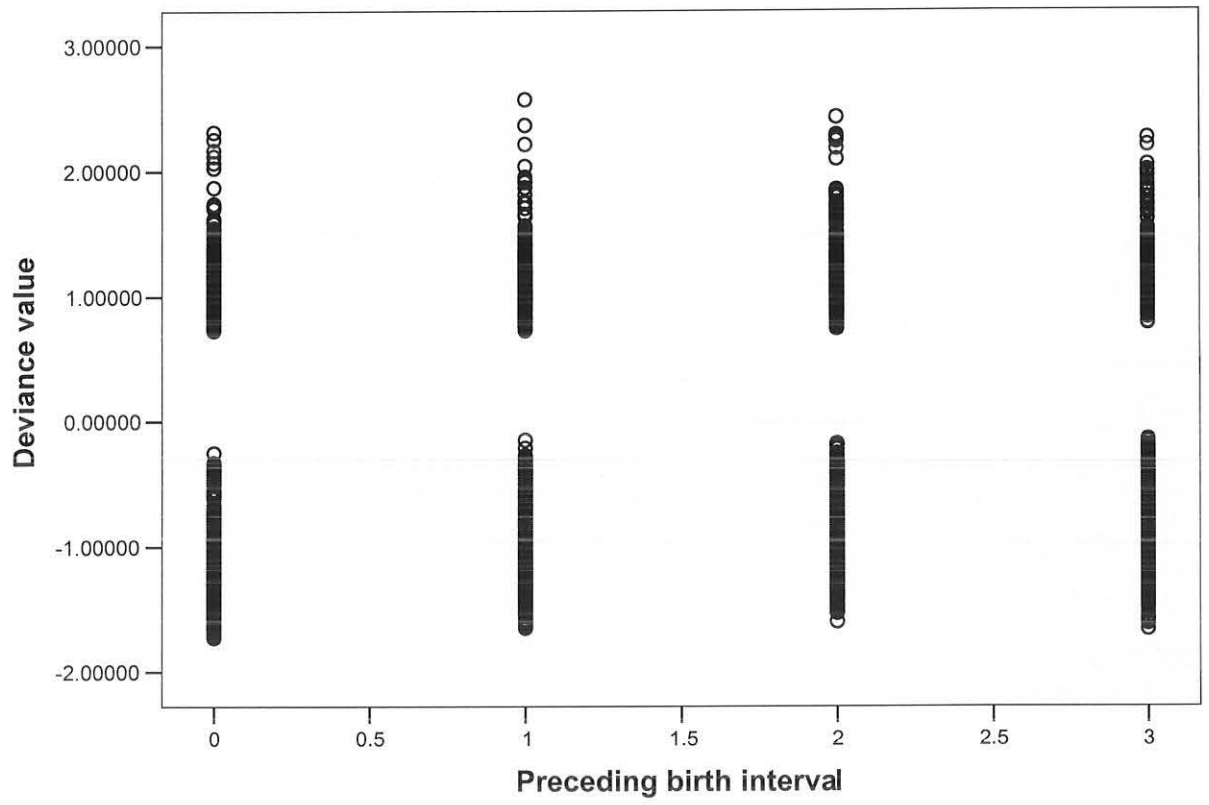
### Deviance value against Household economic status



Deviance value against Age of child



Deviance value against Preceding birth interval



## DECLARATION

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

**Name: Dejen Tesfaw**

**Signature:**  \_\_\_\_\_

**Place: Faculty of Science, Addis Ababa University**

**Date: July, 2008**

This thesis has been submitted for examination with my approval as a University advisor.

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Fentaw Abegaz/ Ph.D. /