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DETERMINANTS AND TRENDS OF STUNTING AMONG UNDER-FIVE CHILDREN IN ETHIOPIA

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Declaration

I, Abdisa Jura, do hereby declare that this thesis entitled "Determinants and Trends of Child Stunting among Under-Five Children in Ethiopia" is entirely my own original work and has not been presented for higher degree at any other University or Institute anywhere for that award of any academic degree, diploma or certificate. All references made to works of other persons have been duly acknowledged.

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This thesis has been submitted for examination with my approval as a university advisor.
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This is to certify that the thesis prepared by Abdisa Jura, entitled: **Determinants and Trends of Child Stunting among Under-Five Children in Ethiopia** and submitted in partial fulfillment of the requirements for the Degree of Master of Science in Statistics complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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List of Abbreviations

AIC: Akiake Information criteria

ANOVA: Analysis of Variance

BMI: Body Mass Index

CSA: Central Statistical Agency

D: Deviance

df: degree freedom

EA: Enumeration Area

EDHS: Ethiopian Demographic and Health Survey

EDRI: Ethiopian Development Research Institute

ICC: Intra-class correlation

LRT: Likelihood Ratio Test

MANOVA: Multivariate Analysis of Variance

OR: Odds Ratio

HAZ: Height for –Age Z-scores

SD: Standard Deviation

UNICEF: United Nations Children's Fund

USAID: United States Agency for International Development

WAZ: Weight for-Age Z-scores

WHO: World Health Organization

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Abstract

DETERMINANTS AND TRENDS OF STUNTING AMONG UNDER-FIVE CHILDREN IN ETHIOPIA

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ADDIS ABABA UNIVERSITY, 2018

Child stunting is one of the most critical issues at global level. It is the most prevalent form of child malnutrition, affecting millions of children globally. It is a scourge that has early beginnings and far-reaching consequences. Stunted children have stunted brains and live stunted lives, hampering the development of entire societies. The irreversible physical and neuron-cognitive damage that accompanies stunted growth poses a major threat to human development. The main objective of this study was to examine the trends and identify determinants of stunting among under-five children in Ethiopia using the four Ethiopian Demographic and Health Survey (EDHS) data (2000, 2005, 2011 & 2016). The statistical methods of data analysis were profile Analysis, binary logistic regression and multilevel logistic regression model. The analysis result revealed that the prevalence rate of stunting among under-five children declined from 71.5% to 38.3% from 2000 to 2016. For the 2000 survey year, region, place of residence, parental education level, source of drinking water, number of children in the family, current contraceptive method, parental occupation, birth order of a child, sex, had cough in last two weeks before survey and age of a child were found to be significant determinants of child stunting whereas whether the child had fever in last two weeks before survey was not significant. Marital status, birth order of a child and had cough in last two weeks before survey were found to be not significant for the 2005 survey years among all included variables whereas all included variables were found to be significant for the 2011 and 2016 survey years. This indicates that the determinants of child stunting were not consistent over time. This study revealed that child stunting has approximately declined over time even though the decrement is not fast enough. Profile Analysis (profile plot) supported this idea. The study revealed that the prevalence of child stunting was highest in Tigray region. Multilevel random coefficient model is better compared to empty (null) model and random intercept model in fitting the data. The intra correlation coefficient suggests that there is variation of child stunting status across the region of Ethiopia. In order to formulate policies to control the child stunting in Ethiopia, it is important not only to understand the incidence of stunting among the children, but also how it differs with demographic and economic characteristics and its trends over time.

1. INTRODUCTION

1.1 Back Ground of the Study

The World Health Organization (WHO, 2006) refers to malnutrition as “failure of cells to perform their physical functions due to inability to receive and use the energy and nutrients needed in terms of amount, mix and timeliness”.

Nutritional status is a result of complex interaction between food consumption and the overall status of health care practices. Numerous socio-economic and cultural factors influence pattern of feeding children and the nutritional status of women and children. Poor nutritional status of children has been a serious problem in world for many years (WHO, 2016).

Feeding practices affect children’s nutritional status, which in turn affect the risks of death. Breastfeeding is important for both the mother and the child. According to 2016 Ethiopian Demographic and Health Survey (EDHS), the feeding practices of only 7 percent of children age 6-23 months met the minimum acceptable dietary standards. Only 14 percent of children had an adequately diverse diet.

Few challenges facing the global community today match the scale of malnutrition, a condition that directly affects one in three people.

Malnutrition and diet are by far the biggest risk factors for the global burden of disease: every country is facing a serious public health challenge from malnutrition. Countries have agreed on targets for nutrition, but despite some progress in recent years the world is off track to reach those targets (Global nutrition report, 2016).

Stunting refers to a child who is too short for his/her age. It is the failure to grow both physically and cognitively and is the result of chronic or recurrent malnutrition. Its effects often last a lifetime. The global trend in stunting and numbers of children affected is decreasing, but not fast enough. Globally, it is estimated that 162 million under-five year old children are stunted. Nearly one quarter of all stunted children live in the developing countries (UNICEF, 2015).
In 2016, more than half of all stunted children under five lived in Asia and more than one third lived in Africa (UNICEF, 2017). Africa is known to have the highest prevalence of stunting in the world and the trend shows stagnating rather than progressing (Zelalem, 2014).

Height-for-age (stunting) is a measure of linear growth retardation and cumulative growth deficits. It is the most prevalent form of child malnutrition, affecting millions of children globally. Millions of children are still suffering from its functional consequences. It is a scourge that has early beginnings and far-reaching consequences. Stunted children have stunted brains and live stunted lives, hampering the development of entire societies (De Onis and Branca, 2016).

The Ethiopian demographic and health survey (EDHS, 2016) descriptively reported that child malnutrition had reduced between the year 2000 and 2016. Stunting has decreased considerably from 58% in 2000 to 38% in 2016, an average decline of more than 1 percentage point per year.

In Ethiopia nationally, 38% of children under age five were stunted (short for their age); 10% were wasted (thin for their height) and 24% were underweight (thin for their age) (EDHS, 2016). A significant regional variation also exists in the proportion of children who receive the minimum acceptable diet, with the highest level of 27% in Addis Ababa and the lowest levels (2-3%) in Affar, Somali, and Amhara (EDHS, 2016). But as per the global trend of child malnutrition, Ethiopia has seen very slow progress (Ahmed et al, 2017).

Stunting covers high percentages of malnutrition as revealed by various studies (Onis et al., 2016; Matanda et al., 2014; Ahmed et al., 2017, EDHS reports) and it also has a long term effect. Understanding socio-economic specific trends and determinants of stunting are important in designing and targeting intervention and improved nutritional outcomes. Therefore, this study assessed trends of stunting and determinants in Ethiopia using the four surveys (EDHS) covering the period from 2000 to 2016.

1.2 Statement of the Problem

Malnutrition continues to be a significant public health and development concern not only in developing country but also in the world (Bantamen et al., 2014).

Stunting rates are dropping, but 159 million children around the world are still affected. The irreversible physical and neuron-cognitive damage that accompanies stunted growth poses a major threat to human development. Despite global consensus on how to define and measure it, stunting often goes unrecognized in communities where short stature is the norm as linear growth

is not routinely assessed in primary health care settings and it is difficult to visually recognize it (De Onis and Branca, 2016).

Trends of stunting are not well studied in Ethiopia as studies on this area either use one survey or are mainly descriptive. Researches on the trends of malnutrition are important due to lack of in-depth studies that use the existing surveys to assess the trends of child stunting in Ethiopia. Although the determinants of child stunting have been reported in Ethiopia, it is not well understood if the factors are consistent over time or if there have been any changes, considering the rapidly changing economic and socio-demographic characteristics of the population, influenced by technological advances and rural-urban migration, among other factors.

Majority of the studies conducted in this area did not account for clustering nature of the EDHS data. Therefore, this study examined the determinants (socio-economic, demographic, health and environmental) and trends of stunting among under-five children in Ethiopia by using profile analysis and multilevel Logistic regression model.

1.3 Significance of the Study

Malnutrition is a detrimental condition that must be addressed quickly and comprehensively. Understanding socio-economic specific trends and determinants of stunting are important in designing and targeting intervention that enables to obtain improved nutritional outcomes (Rabbani et al., 2014). Stunting is one of the major causes of morbidity among under-five children.

This study used the efficient statistical models to identify the determinants and trends of stunting using the four EDHS surveys (EDHS 2000, 2005, 2011 & 2016). Therefore, it might create awareness on the appropriate statistical methods to be used in similar studies.

Additionally, the results of this study would contribute to the growing of body of knowledge about trends and factors influencing stunting in under-five children in Ethiopia. It might also influence the formulation of appropriate policies aimed at addressing the problem of stunting.

1.4 Objectives of the Study

1.4.1 Main Objective

The primary objective of the study was to examine trends and identify determinants of stunting among under-five children in Ethiopia.

1.4.2 Specific Objectives

The specific objectives were:

- ✓ To examine stunting trends over time.
- ✓ To examine the extent of the variation in stunting within and between regions of Ethiopia.

1.5 Scope of Study

This study was based on the four Ethiopian Demographic and Health Survey (EDHS 2000, 2005, 2011 & 2016) conducted by the Central Statistical Agency (CSA). The survey covered Ethiopia as a whole, urban and rural areas of Ethiopia (each as a separate domain), and all nine regions (Tigray, Afar, Amhara, Oromia, Somali, Benishangul-gumuz, Harari, Gambela and SNNPR) and the two city admirations (Addis Ababa and Dire Dawa).

2. LITERATURE REVEW

2.1 Over View of Stunting

Malnutrition refers to deficiencies, excess or imbalance in person's intake of energy and/or nutrients. The term malnutrition covers two broad groups of conditions: 'under-nutrition' and 'over-nutrition'. 'Under-nutrition' includes: stunting (low height-for-age), wasting (low weight for- height), underweight (low weight-for-age) and lack of important vitamin or minerals. The other includes overweight, obesity and diet related non- communicable disease such as heart disease, stroke, diabetes, and cancer (WHO, 2016).

Malnutrition results from the interaction of poor quality of diet or poor quality of health and care environments. An estimated 45% of deaths in under-five children are linked to malnutrition. Malnutrition and diet are now the largest risk factors responsible for the global burden of diseases (Global Nutrition Report, 2016).

According to UNICEF (2013), Poor nutrition in the first 1,000 days of children's lives can had irreversible consequences. For millions of children, it means they are, forever, stunted. Smaller than their non-stunted peers, stunted children are more susceptible to sickness.

Stunting is the devastating result of poor nutrition in early childhood. Children suffering from stunting may never grow to their full height and their brains may never develop to their full cognitive potential. Although it seems declining slowly, only in 2017, around 155 million children under the age of five suffer from stunting globally (UNICEF, 2017).

According to Ethiopian Demographic and health survey (EDHS, 2016), 38% of children under age five were stunted or too short for their age. Children who were smaller at birth were more likely to be stunted. The survey also specified that the proportion of children who were stunted decline with mother's education.

Stunting and other forms of malnutrition were clearly major contributing factors to child mortality, diseases and disability. Child feeding, incidence of infection diseases, mother's nutrition and health status were important determinants of stunting (UNICEF, 2013). Stunting had decreased considerably from 58 percent in 2000 to 38 percent in 2016. The 206 EDHS also

revealed that the proportion of children who were stunted declines with improving mother's education and household health, among others.

2.2 Empirical Literature Review

A study conducted in Kenya reported significant declines in underweight, but trends in wasting and stunting were stagnant in Kenya. The study analyzed using the classical logistic regression identified child's sex; age and household wealth index as statistically significant factors (Matanda et al., 2014).

Habaasa (2015) conducted a study in Uganda on "factors associated with malnutrition among under-five children" and reported that stunting was found to be the most malnutrition condition in Uganda. According to the study, children of pleasant farmers were more likely to be stunted than pastoralist's family. A binary logistic regression model was fitted to ascertain the factors associated with malnutrition and age of child, birth order, birth interval, sex of the child and mother's occupation were significantly associated with stunting.

A study conducted in Ethiopia by Ethiopian Development Research Institute revealed that levels Household assets, maternal and paternal education, antenatal care, birth intervals, water quality and water facilities were the predictors of malnutrition using data from 2000 and 2011 EDHS. The study showed that trends of stunting declined from 2000 to 2014 (58% of children were stunted in 2000, 44% in 2011 and 40% in 2014) (EDRI, 2014).

A related study done by Dereje (2011) in Sidama zone of Ethiopia, using multinomial logistic regression, indicated that factors such as educational level of the mother, occupational status of the mother, age of the child, number of family members source of drinking water, type of toilet facility, sex of child, birth interval, breastfeeding practice and health status of child were statistically significant in determining nutritional status of children under age five.

A study conducted in Ethiopia using multilevel logistic regression identified those children from households in Tigray, Afar and Amhara regions were less nourished. Level of education of parents, possession of media infrastructure, assets of Household, contraceptive adoption, the condition of sanitation and water were considered to be important determinants of nutritional status of children (Ali et al., 2016).

A study conducted in Kombolcha district of eastern Hararghe, Ethiopia reported that the prevalence of stunting (<-2HAZ), underweight (<-2WAZ) and wasting (<-2WHZ) is 48%, 28.9% and 11.2% respectively. The study indicated that child nutritional status is strongly associated with the child's age, gender, immunization status and the mother's use of antenatal care, farm size, household size, water source, latrine use and incidence of morbidity (Tadiwos et al., 2013)

A study by Workineh and Teshome (Workineh, 2016 unpublished AAU thesis) on "Analysis of Risk Factors for Under-Five Child Malnutrition in Ethiopia" revealed that the prevalence of under-five child malnutrition was still high in Ethiopia and demonstrated that child malnutrition was mostly determined by socio-economic, demographic and maternal related factors.

3. DATA AND METHODOLOGY

3.1 Data Source

The data used to assess the trends and determinants of stunting among under- five children in Ethiopia were the four EDHS data collected by the Central Statistical Agency (CSA). So far four DHS were conducted in Ethiopia: 2000, 2005, 2011 and 2016. All surveys used two stage sampling i.e initially EAs were selected and at the second stage Households were selected per EAs. The first two surveys used systematic sampling technique while the last two surveys used stratified sampling technique. The surveys took nationally representative sample of 14,642, 14,645, 17,817 and 18,008 Households respectively. In this study, sampling weights that helps to get efficient estimates in surveys like EDHS could not be used as the weights given in the data are for households not for children.

3.2 Study Variables

3.2.1 The Response Variable

The response variable is stunting status of under-five children in Ethiopia. Child stunting status was assessed by height for-age z-scores using the new WHO Child Growth Standards. A child is considered as stunted if his/her height-for-age z-scores is less than −2 standard deviations from the median of the reference population. The z-score was computed by using the World Health Organization recommended reference population (WHO, 2006). The HAZ of a child is the difference between the Height of the child and the median Height of the reference population of the same age and sex, divided by the standard deviation (SD) of the Height of same group of children: Often, binary outcome is preferred as a response of interest as it is easy for interpretation. Therefore, the outcome variable (stunting status) was studied as a binary response which can be categorized as $y = \begin{cases} 1, & if\ child\ is\ stunted\ (\mathrm{Z-score} < -2\mathrm{SD}) \\ 0, & if\ child\ is\ not\ stunted\ (\mathrm{Z-score} \geq -2\mathrm{SD}) \end{cases}$

3.2.2 Explanatory Variables

Independent variables/factors expected to influence child stunting in Ethiopia are:

- Socio-economic variables: maternal/paternal education and occupation, place of residence, region, mother's marital status
- Health and environmental characteristics: source of drinking water, modern contraceptive methods
- Child caring practices: health status of child for past two weeks before survey

- Demographic variables: age of child, sex of child and birth order, number of living children in the family

3.3 Methods of Data Analysis

In this study both exploratory (descriptive) and inferential statistical data analysis methods were employed.

3.3.1 Exploratory Data Analysis

Descriptive statistics like frequency table, percent and graph were used to observe a possible link between explanatory variables and stunting.

3.3.2. Statistical Data Analysis

3.3.2.1 Profile Analysis

Profile analysis is a multivariate technique for analyzing the shape (profile) of variables across groups. It is the repeated measures extension of Multivariate Analysis of Variance (MANOVA) where a set of dependent variables are commensurate (expressed on the same scale). Typically, this analysis is done with data that has been collected over time and when we are interested in seeing whether there is a general linear trend (repec.org/bos2014/boston14_ender.pdf, 2014).

The set of dependent variables can either come from one dependent variable measured several different times, or several different dependent variables all measured at one time. The more common application is in research where subjects are measured repeatedly on the same dependent variable. One way to produce commensurability is to use standardized scores, such as z-scores, instead of raw scores for the dependent variables.

In this case, each dependent variable is standardized using the pooled within-groups standard deviation. In the choice between univariate repeated-measures ANOVA and profile analysis, sample size per group is often the deciding factor. ANOVA is used to compare two or more means to see if there are any statistically significant differences among them (Tabachnick and Fidell, 2010).

Profile analysis is used to answer the question like: Are the profiles parallel? (Look for the interaction), If the profiles are parallel, then are they coincident? (Did the groups score the same on each variable? (Look for the between group difference), If the profiles are coincident, then is the profiles level? (Are the means on all variables equal to the same constant)? (Look for the

different on the within subjects factor).There is one major question asked by profile analysis; Do groups have similar profiles on a set of dependent variables? In our case, group may be formed by region, sex or age.

Profile analysis is helpful in determining the nature of differences between two or more groups. Profile analysis is most commonly used in two cases: comparing the same dependent variables between groups over several time-points and when there are several measures of the same dependent variable. Profile analysis uses plots of the data to visually compare across groups and remains an important methodology for uncovering common patterns.

Tests Performed in Profile Analysis

There are different tests that are performed in a profile analysis. These are: Test of Parallelism, Test of Levels (Group differences) and Test of Flatness.

Test of Parallelism: Do different groups have parallel profiles? This is commonly known as the test of parallelism and is the primary question addressed by profile analysis.

Test of levels (group differences): If we have parallelism, then we can test whether there is a difference in the groups. Whether or not groups produce parallel profiles, does one group, on average, score higher on the collected set of measures than another?

Test of flatness: Do all the dependent variables elicit the same average response? This question is typically relevant only if the profiles are parallel. If the profiles are not parallel, then at least one of them is necessarily not flat. The flatness test evaluates whether stunting changes over the period of time.

Assumption of profile analysis

Multivariate normality: If the distributions of dependent variables show marked, highly significant skewness some normalizing transformations is considered.

Absence of Outliers: Tests for univariate and multivariate outliers is applied to the dependent variable.

Homogeneity of Variance-Covariance Matrices: Box’s M test is used as a preliminary test of the homogeneity of the variance-covariance matrices.

Linearity: This assumption is evaluated by examining scatter plots between all pairs of dependent variables.

3.3.2.2 Analysis Ignoring Clustering Effect (Logistic Regression)

Logistic regression modeling approach is used when the dependent variable is dichotomous or polytomous (Agresti, 2007). Since logistic regression calculates the probability of success over the probability of failure, the results of the analysis are in the form of odds ratio. Logistic regression also provides knowledge of the relationships and strengths among the variables.

3.3.2.2.1 Binary Logistic Regression

Binary (or binomial) logistic regression is a form of regression which is used when the dependent is a dichotomy and the independents are of any type. For a binary response variable Y (stunting status) where Y_i=1 if child is stunted (Z − score < −2SD) and 0 if child is not stunted (Z − score ≥ −2SD) and an explanatory variable X, let p(x) =P(Y=1/X=x) =1−P(Y=0/X=x).Generally relationship between p(x) and x are nonlinear. Then, the multiple binary logistic regression model is given by:

$$\log\left[\frac{p(x)}{1-p(x)}\right] = logit[p(x)] = \beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k \quad \text{..... (3.1)}$$

3.3.2.2.2 Methods of Parameter Estimation

In a very general sense, the method of maximum likelihood yields values for the unknown parameters which maximize the probability of obtaining the observed set of data. In order to apply this, we must first construct a function called likelihood function. The maximum likelihood estimators of these parameters are chosen to be those values which maximize this function. Thus, the resulting estimators are those which agree most closely with the observed data. Maximum likelihood estimation was the method of parameter estimation used in this study.

3.3.2.2.3 Assessing the Goodness of Fit

Measures of goodness of fit are statistical tools used to explore the extent to which the fitted response obtained from the postulated model compares with the observed data. Likelihood ratio test (LRT), Hosmer-Lemeshow test and Wald tests are most commonly used as measures of goodness of fit for categorical data (Hosmer andLemeshow1989).

Likelihood Ratio Test

The likelihood ratio test statistic (G^2) is the test statistic commonly used to assess the overall fit of the logistic regression model test which is appropriate for a variety of types of statistical models (Agresti, 1996). The likelihood-ratio test statistic is given by:

$$G^2\text{=-2 log } (L_0/L_1) = -2\ [l_0 - l_1]$$

Where, L_0 and L_1 are the maximized likelihood functions under the null hypothesis and under functions under the null hypothesis and under the full model, respectively. Under the global null hypothesis, H_0: $\beta_1 = \beta_2 = ... = \beta_k = 0$ the statistic G^2 follows a chi-square distribution with p degrees of freedom and measures how well the independent variables affect the response variable (Hosmer and Lemeshow, 2000). The null and alternative hypotheses maybe stated as:

H_0: The model is not a good fitting model (i.e. the predictors do not have a significant effect).

H1: The model is a good fitting model.

Then, the p-values are used to reject or not reject the null hypothesis.

Hosmer and Lemeshow test

The Hosmer-Lemeshow test is another alternative to check model fit. This test is also called the chi-square test **(**Agresti, 2002**).** The Hosmer-Lemeshowtest statistic is given by:

$$\hat{C} = \frac{\sum_{k=1}^{g} (Ok - Ek)^2}{\mathrm{V}k}$$

Where g is the number of group, O_k is observed number of events in the k^{th} group, E_k is expected number of events and V_k is a variance correction factor for the k^{th} group. This statistic $\hat{C}$ has an approximate chi-square distribution with (g-2) degrees of freedom. If the p-value of the Hosmer-Lemeshow goodness-of-fit test statistic is greater than 0.05, we will not reject the null hypothesis implying that the model estimates are adequate to fit the data.

Wald statistic (tests of the significance of coefficients)

The Wald test is one of a numbers of ways of testing whether the parameters associated with a group of explanatory variables are zero (Agresti, 2007). It is used to test the significance of individual coefficients in the model and given by:

$$W = \left[\frac{\hat{\beta}}{se(\hat{\beta})}\right]^2$$

For studies with small sample sizes, the likelihood ratio test is more reliable than this test (Agresti, 2002). This statistic has an approximate chi-square distribution with one degree of freedom. As a result, we employed this method in testing the significance of the coefficients.

3.3.2.2.4 Model Diagnostics: Influential Observations and Outliers

Model diagnostic procedures involve both graphical methods and formal statistical tests. These procedures allow us to explore whether the assumptions of the regression model are valid and decide whether we can trust subsequent inference results. The following methods are used for model diagnostics in our study.

Outlier detection

An outlier is an observation that deviates so much from other observations as to arouse suspicion that it was generated by a different mechanism. An observation is influential if it is individually or together with several other observations, has a demonstrably larger impact on the calculated values of various estimates than is the case for most of the other observations. Detecting outliers is a common practice and it is important because outliers can affect the regression model in two ways: outliers may almost uniquely determine regression coefficients; they may also cause the standard errors of regression coefficients to be much smaller than they would be if the observation were excluded.

There are two types of outliers, so that it is important to distinguish between the two types. Outliers in the response variable represent model failure. Outliers with respect to the predictors are called leverage points (Vittinghoff et al, 2005).

Leverage (hat matrix): an observation with an extreme value on the predictor variable is called a point with high leverage. Leverage is a measure of how far an observation deviates from the mean of that variable. These leverage points can have an effect on the estimate of regression coefficients.

Influential Statistics: Influential values are points that have exerted excessive influence on the regression coefficient estimates. Influential measures will be used to identify cases that are highly influential on the logistic regression estimates. An influential point affects the statistical significance as well as the strength and direction of the association between a response variable and predictor variables.

DFBETAS: DFBETA(S): is a diagnostic measure which measures the change in the logit coefficients for a given variable when a case is dropped. If DFBETAs is less than unity, there is no specific impact of an observation on the coefficient of a particular predictor variable, while DFBETA of a case greater than 1 implies the observation is an outlier (Cook and Weisberg, 1982).

Cook's distance (D): Cook's distance is a measure of the influence of a case. A large Cook's distance indicates that excluding a case from computation of the regression statistics changes the coefficients substantially (Cook and Weisberg 1982).Cook's distance less than unity shows that an observation had no overall impact on the estimated vector of regression coefficients β.

3.3.2.3 Analysis Adjusted for the Clustering Effect (Multilevel Analysis)

Multilevel analysis is a methodology for the analysis of data with complex patterns of Variability, with a focus on nested sources of variability. It is used when the data structure is hierarchical that is individual are nested within the groups (Hox, 2010).

Nutrition data has this nature of data in which individuals (children) are nested in the groups (region). As a result, Multi-level logistic model was applied to accounts for the variation within and between the groups.

Multilevel models (also known as hierarchical linear models, nested data models, mixed models, random coefficient, random-effects models, random parameter models, or split-plot designs) are statistical models of parameters that vary at more than one level. Multilevel models can be used

on data with many levels, although the two-level models are the most common. The dependent variable must be examined at the lowest level of analysis (Hox, 2010).

3.3.2.3.1 Two-Level Model

Let y_{ij} be the binary outcome variable for individual i in region j, coded as '0' or '1', associated with level-one unit i nested within level two unit j. Also let p_{ij} be the probability that the response variable equals 1 or p_{ij} = Pr (y_{ij} = 1). Here, y_{ij} follows a Bernoulli distribution. Like the logistic regression, the p_{ij} is modeled using the link function, logit. Therefore the two-level logistic regression model can be written as:

$$\text{Log}\left[\frac{p_{ij}}{1-p_{ij}}\right] = \beta_0+\beta_1 x_{ij}+u_{0j} \quad \text{..... (3.2)}$$

where u_{0j} is the random effect at level 2. Without u_{0j} this equation can be considered as a standard logistic regression model. Therefore, conditional on $u_{0j,}$ y_{ij} can be assumed to be independently distributed. Here, u_{0j} is a random quantity and follows N (0, δ_u^2).

3.3.2.3.2 The Empty multilevel Logistic Regression Model

The empty two-level model for a dichotomous outcome variable refers to a population of groups (level-two units (regions)) and specifies the probability distribution for group-dependent probabilities p_j in $y_{ij} = p_j + e_j$ without taking further explanatory variables into account. 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_j), by the formula;

$$f(p_j) = \beta_0+U_{0j} \text{.....(3.3)}$$

Where β_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;

$$\text{Logit}(p_j)= \beta_0+ U_{0j} \text{.....(3.4)}$$

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

This model decomposes the total variance in the outcome in to two parts i.e. an individual variance captured by the individual level error term, and a group variance, the group level error term. The unconditional model is therefore being useful for investigating the amount of variation that exists within and between groups. One way to quantify this is to calculate the intra-class correlation coefficient (ICC), which represents the proportion of the total variance that is attributable to between group differences and it provides an assessment of whether or not significant between groups variations exists. Then, the intra-class correlation (ICC) at regions level is given by:

$$\rho = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_e^2} \quad \text{(3.5)}$$

Where σ_u^2 is the between group variance which can be estimated by U_{0j} and σ_e^2 is within group variance (John, 2009).

Denote by π_0 the probability corresponding to the average value β_0 as defined by $f(\pi_0) = \beta_0$ for the logit function, the so-called logistic transformation of β_0, is defined by;

$$\pi_0 = \text{logistic}(\beta_0) = \frac{e^{\beta 0}}{1+e^{\beta 0}} \quad \text{(3.6)}$$

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

$$\text{Var}(p_j) = \pi_0(1- \pi_0)^2 \sigma_o^2 \quad \text{(3.7)}$$

Note that an estimate of population variance var(p_j) can be obtained by replacing sample estimates of π_0 and σ_o^2. The resulting approximation can be compared with the non-parametric estimate (Snijders and Bosker, 1999):

$$\tau^2 = s_{between}^2 - \frac{s_{within}^2}{\hat{n}} \quad \text{(3.8)}$$

Chi-square test can be used to test if the variance of population is equal to as specified value. Hypothesis: H_0: There is no regional variation on child stunting status in Ethiopia Vs. H_1: There is a regional variation on child stunting in Ethiopia

3.3.2.3.3 Random Intercepts Model

A random intercepts model is a model in which intercepts are allowed to vary, and therefore, the scores on the dependent variable for each individual observation are predicted by the intercept that varies across groups (region in this study). This model assumes that slopes are fixed (the same across different contexts) (Hox, 2010). It is used to model unobserved heterogeneity in the overall response by introducing random effects. In the random intercept model, the intercept is the only random effect meaning that the groups differ with respect to the average value of the response variable, but the relation between explanatory and response variables cannot differ between groups. The 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;

$$\text{logit}(p_{ij}) = \beta_{0j} + \beta_{1j}x_{1ij} + \beta_{2j}x_{2ij} + \ldots + \beta_{kXijk} \ldots\ldots\ldots\ldots(3.9)$$

$= \beta_{0j} + \sum_{h=1}^{k} \beta_{hj}x_{hij}$, $i = 1,2,\ldots,n$, $j = 1,2,\ldots,11$. Where p_{ij} is the probability of child stunting, the intercept term β_{0j} is assumed to vary randomly and is given by the sum of an average intercept β_0 and group-dependent deviations U_{0j}, that is $\beta_{0j} = \beta_0 + U_{0j}$. As a result we have:

$\text{logit}(p_{ij}) = \beta_0 + \sum_{h=1}^{k} \beta_{hj}x_{hij} + U_{0j}$ Solving for p_{ij} we have:

$$p_{ij} = \frac{e^{\beta_0 + \sum_{h=1}^{k} \beta_{hj}x_{hij} + U_{0j}}}{1 + e^{\beta_0 + \sum_{h=1}^{k} \beta_{hj}x_{hij} + U_{0j}}} \ldots\ldots\ldots\ldots (3.10)$$

This equation does not include a level-one residual because it is an equation for the probability p_{ij} rather than for the outcome y_{ij}. Where $\beta_0 + \sum_{h=1}^{k} \beta_{hj}x_{hij}$ is the fixed part of the model and U_{0j}

is called the random or the stochastic part of the model. It is assumed that the residual $U_{0\,j}$ is mutually independent and normally distributed with mean zero and variance σ_u^2 **(**Snijders and Roel ,1999).

3.3.2.3.4 Random slopes (coefficients) 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. The random coefficients builds up on the random intercept model by allowing the effects of individual predictors to vary randomly across level 2, that is, level 1 slope coefficients are allowed to take on different values in different aggregate groupings. In the random coefficient model both the intercepts and slopes are allowed to differ across the region.

The multilevel random effect coefficients logistic regression model is based on linear models for the log odds that include random effects for groups or other higher levels. Based on the logistic regression equation, we can write the multilevel models as:

$\text{logit}(p_{ij}) = \log(\frac{pij}{1-pij}) = \beta_{0j} + \beta_{1j}x_{1ij} + \beta_{2j}x_{2ij} + \ldots + \beta_{kj}x_{kij}$ ……(3.11)

Where $\beta_{0j}=\beta_0+u_{oj}$ and $\beta_{hj} = \beta_h+u_{hj}$, h=1,2,...,k.

From the above equation, we have $\text{logit}(p_{ij}) = \beta_0 + \sum_{h=1}^{k} \beta_{hj}x_{hij} + U_{0j} + \sum_{h=1}^{k} u_{hj}\, x_{1ij}$

Where the first part of equation, $\beta_0 + \sum_{h=1}^{k} \beta_{hj}x_{hij}$ is called the fixed part of the model and the second part $U_{0j} + \sum_{h=1}^{k} u_{hj}\, x_{1ij}$ is called the random part of the model.

3.3.2.3.5 Methods of Estimation for Multilevel Logistic Regression

Estimation of parameters (regression coefficients and variance components) in multilevel modeling is mostly done by the maximum likelihood method. Other estimation methods that have been used in multilevel modeling are generalized least squares (GLS), generalized estimating equations (GEE), and Bayesian methods such as Markov chain Monte Carlo

(MCMC)(Hox, 2010). Since it is the common method, this study used the maximum likelihood method.

3.4 Methods of Model comparisons

3.4.1 Deviance Based on Chi-square

The deviance based chi-square value for two models is obtained as two times the deviance of log-likelihood value of the two models.

The basic concept underlying this procedure is to compare the maximum likelihood under an assumed model with that of baseline model. Let $\hat{L}c$ is maximum likelihood under the current model. The statistic cannot be used on its own to assess the lack of fit of the current model unless compared with corresponding statistic of an alternative baseline model for the same data. This latter model is taken to be a model that fits the data perfectly. Such a model have the same number of unknown parameters as there are observation the model is termed as full or saturated and maximized likelihood. It is denoted by $\hat{L}f$. The saturated model does not condense the information in the bulk of data into as a simple summary as it is not parsimonious.

However, the maximum likelihood under this model is an automatically appealing reference by which a corresponding value of a given model can be compared to assess the adequacy of the given model. Let statistic D be defined as;

D = -2log($\frac{\hat{L}c}{\hat{L}f}$)= -2log (log$\hat{L}c - log\,\hat{L}f$)……. (3.12)

Large value of D encountered when $\hat{L}c$ is small relative to $\hat{L}f$ indicating that the current model is a poor one. On the other hand, small value of D is obtained when $\hat{L}c$ is similar $\hat{L}f$, indicating that the current model is a good one.

The statistic D has chi-square distribution at degree freedom equal to the difference between the number of parameters in full model and current model therefore, it measures the degree to which the current model deviates from the full model and is termed as the deviance.

3.4.2 Akaike information criterion (AIC)

The Akaike information criterion is a measure of the relative quality of statistical models for a given set of data. And it is the expected estimated relative Kullback-liebler (K-L) distance, where the K-L distance is the minimum distance between models and it is given as:

AIC = -2ln (L (model)) +2r ……. (3.13)

Were, r is the number of estimated parameters and L(model) is likelihood of the model.

3.4.3 Bayesian information criterion (BIC)

It is also known as the Schwarz criterion after Gideon Schwarz and virtually identical to minimum description length criterion. The formula is given as;

BIC = -2ln ((L(model))+r*log(n)……(3.14)

Where, r is the number of estimated parameters, L(model) is likelihood of the model and n is number of observations.

CHAPTER FOUR
4. STATISTICAL DATA ANALYSIS AND RESULTS

This chapter presents the results of the study. The first Section presents descriptive statistics of the variables included in the study. Analysis was carried out for the four EDHS surveys separately and then combined for trend analysis. The second Section presents the profile plots (profile analysis) to see trends of stunting among children under-five and multilevel logistic regression results. The last part is discussion of the results.

4.1. Exploratory Data Analysis

In order to have an overall picture of child stunting in Ethiopia, we start with exploratory data analysis of the variables included in the study. The total numbers of children under age five years covered in the study were 8,525, 3,856, 9,519 and 8,703 for 2000, 2005, 2011 and 2016 respectively.

Nutritional progress has been somewhat uneven across Ethiopia. The prevalence rate of stunting among under-five children declined from 71.5% to 38.3% from 2000 to 2016. The risk of stunting seemed decreasing over time for most of the determinants. The risk for stunting in urban decreased from 65.7% to 35.8% (Table 4.1 and Table for 2000 survey). See Appendix A for the 2000, 2005 and 2011 years of survey. Higher proportions of rural children were stunted in all survey years than urbans. The risk of stunting for sex decreased from 2000 to 2016. The risk of stunting in males decreased from 73% in 2000 to 41% in 2016. The percentage difference is less for females. It is 5.5% for the 2016 survey.

Differences in stunting were also observed among regions. In all surveys, the smallest proportion of stunting, about 31.1% and 32.6% for 2016 were seen in Dire Dawa and Addis Ababa. The highest proportion of stunting, about 79.8% (2000 survey), was observed in Tigray region. Our results showed that in each of the three surveys, the smallest proportion in stunting was observed for a child whose parental education level is higher, but not for 2011 survey. Generally, there were variations in stunting status of children for all of the mentioned determinants (see Table 4.1 and Tables for the survey 2000, 2005 and 2011 in Appendix A).

Table 4.1: Distribution of socioeconomic, demographic, and health and environmental related characteristics and stunting status of Ethiopian children for the 2016 Survey Year

		stunting status of a child				
		not stunted	Stunted			
		Count (%)	Count (%)	Chi-square	df	p-value
Region	Tigray	465 (58.8%)	326 (41.2%)			
	Afar	447 (67.1%)	219 (32.9%)			
	Amhara	575 (54.5%)	481(45.5%)			
	Oromia	1238 (66.8%)	616 (33.2%)	81.633	10	<.0001
	Somali	596(59.3%)	409(40.7%)			
	Benishangul	387(61.4%)	243(38.6%)			
	SNNPR	574(58.2%)	413(41.8%)			
	Gambela	266(56.4%)	206(43.6%)			
	Harari	295(62.5%)	177(37.5%)			
	Addis Adaba	283(67.4%)	137(32.6%)			
	Dire Dawa	241(68.9%)	109(31.1%)			
	Total	5367(61.7%)	3336(38.3%)			
Type of place of residence	Urban	1189(64.2%)	664(35.8%)			
	Rural	4178(61.0%)	2672(39.0%)	6.214	1	0.013
	Total	5367(61.7%)	3336(38.3%)			
parental educational level	No education	3435(63.1%)	2006(36.9%)			
	Primary	1021(52.2%)	935(47.8%)			
	Secondary	332(61.5%)	208(38.5%)	141.927	4	<.0001
	Higher	579(75.6%)	187(24.4%)			
	Total	5367(61.7%)	3336(38.3%)			
Source of drinking water	PIPED WATER	39(73.6%)	14(26.4%)			
	piped into dwelling	116(55.5%)	93(44.5%)			
	piped into yard/plot	423(51.5%)	399(48.5%)			
	piped into neighbor	225(60.2%)	149(39.8%)			
	public tab/stand pipe	888(62.9%)	524(37.1%)			
	tube well water	10(32.3%)	21(67.7%)			
	dug well(open/protected)	25(61.0%)	16(39.0%)			
	Protected well	473(64.9%)	256(35.1%)			
	Unprotected well	461(64.9%)	249(35.1%)			
	surface water	151(66.8%)	75(33.2%)			
	Protected spring	430(60.7%)	278(39.3%)	90.239	18	<.0001
	Unprotected spring	843(61.1%)	536(38.9%)			

	river/dam/lake/stream/canal /irrigation channel	825(66.3%)	420(33.7%)			
	Rain water	118(66.3%)	60(33.7%)			
	Tanker truck	132(58.4%)	94(41.6%)			
	cart with small tank	34(57.6%)	25(42.4%)			
	bottled water	78(64.5%)	43(35.5%)			
	Other	44(45.4%)	53(54.6%)			
	not dejure resident	52(62.7%)	31(37.3%)			
	Total	5367(61.7%)	3336(38.3%)			
Number of living children in the family	1-4	3274(61.0%)	2095(39.0%)	6.243	2	0.044
	5-9	1972(63.2%)	1149(36.8%)			
	10 and above	121(56.8%)	92(43.2%)			
	Total	5367(61.7%)	3336(38.3%)			
Current contraceptive method	Not using	3504(64.0%)	1975(36.0%)			
	Pill	121(66.5%)	61(33.5%)			
	IUD	85(64.4%)	47(35.6%)			
	Injections	756(62.0%)	464(38.0%)			
	Diaphragm	164(73.9%)	58(26.1%)			
	Male condom	53(50.0%)	53(50.0%)			
	Female sterilization	25(33.8%)	49(66.2%)			
	Male sterilization	97(46.9%)	110(53.1%)	275.407	12	<.0001
	Periodic abstinence	50(90.9%)	5(9.1%)			
	Withdrawal	1(20.0%)	4(80.0%)			
	Other	169(35.1%)	312(64.9%)			
	implants/Norplant	272(58.7%)	191(41.3%)			
	lactational amenorrhea (LAM)	18(81.8%)	4(18.2%)			
	standard day method	52(94.5%)	3(5.5%)			
	Total	5367(61.7%)	3336(38.3%)			
Current marital status	never in union	248(81.6%)	56(18.4%)			
	Married	4833(61.0%)	3092(39.0%)			
	Living with partner	17(70.8%)	7(29.2%)			
	Widowed	69(66.3%)	35(33.7%)	59.500	5	<.0001
	Divorced	146(55.3%)	118(44.7%)			
	No longer living together/separated	54(65.9%)	28(34.1%)			
	Total	5367(61.7%)	3336(38.3%)			
parental occupation	Not working	1081(57.3%)	804(42.7%)			
	professional/technical/managerial	235(52.1%)	216(47.9%)			

	Clerical	627(66.6%)	315(33.4%)			
	Sales	888(60.5%)	580(39.5%)			
	agricultural self-employee	714(61.2%)	453(38.8%)			
	agricultural employee	362(62.7%)	215(37.3%)	69.152	10	<.0001
	Household and domestic	866(68.0%)	408(32.0%)			
	Services	54(61.4%)	34(38.6%)			
	skilled manual	322(66.1%)	165(33.9%)			
	unskilled manual	198(60.0%)	132(40.0%)			
	Other	20(58.8%)	14(41.2%)			
	Total	5367(61.7%)	3336(38.3%)			
Birth order number of a child	1	992(71.3%)	400(28.7%)	88.670	3	<.0001
	2-3	1652(57.8%)	1204(42.2%)			
	4-5	1304(64.3%)	723(35.7%)			
	6+	1419(58.4%)	1009(41.6%)			
	Total	5367(61.7%)	3336(38.3%)			
Sex of child	Male	2653(59.0%)	1845(41.0%)			
	Female	2714(64.5%)	1491(35.5%)	28.426	1	<.0001
	Total	5367(61.7%)	3336(38.3%)			
Had fever in last two weeks	No	4279(60.2%)	2834(39.8%)			
	Yes	839(65.9%)	434(34.1%)			
	Don't know	249(78.5%)	68(21.5%)	54.759	2	<.0001
	Total	5367(61.7%)	3336(38.3%)			
Had cough in last two weeks	No	4213(62.3%)	2553(37.7%)			
	Yes, last 24 hours	52(69.3%)	23(30.7%)			
	Yes, last two weeks	946(57.8%)	692(42.2%)	19.537	3	<.0001
	Don't know	156(69.6%)	68(30.4%)			
	Total	5367(61.7%)	3336(38.3%)			
Child's age in months	<6months	246(30.1%)	572(69.9%)			
	11-12months	1374(59.8%)	923(40.2%)			
	12-23months	1248(62.7%)	743(37.3%)	584.585	5	<.0001
	24-35months	203(44.3%)	255(55.7%)			
	36-47months	1372(72.2%)	528(27.8%)			
	48-59months	924(74.6%)	315(25.4%)			
	Total	5367(61.7)%	3336(38.3%)			

The bivariate chi-square test results in Tables (Table 4.1 and Tables for 2000, 2005 and 2011 in Appendix A) indicated that all variables are statistically significant at 5% significance level except marital status which is not significant for the 2000 and 2005 surveys. The chi-square test

results show that child stunting is univariately associated with region, place of residence, parental education level, source of drinking water, number of living children in the family, current contraceptive method, parental occupation, birth order number, sex of the child, had fever and cough in last two weeks before survey and age of child.

4.2 Trends of Child Stunting Based on the Four EDHS: Profile Plot for the Selected Variables

In profile analysis, the data are usually plotted with time points on the x-axis and with the response on the y-axis. These plots are then made into profiles lines representing the score across time points or tests for each group.

We examined the profile plot of some selected variables to see the trends or patterns of child stunting covering the period between 2000 and 2016. The profile plots showed a somewhat declining trend in child stunting.

In terms of region, the plot indicated decline in stunting among under-five children even though the decline was not significant (p-value = 0.0028 from Table 4.2) and the regional variation profile is not parallel (see Figure 1). One can see from the plot that child stunting seems higher in Tigray region.

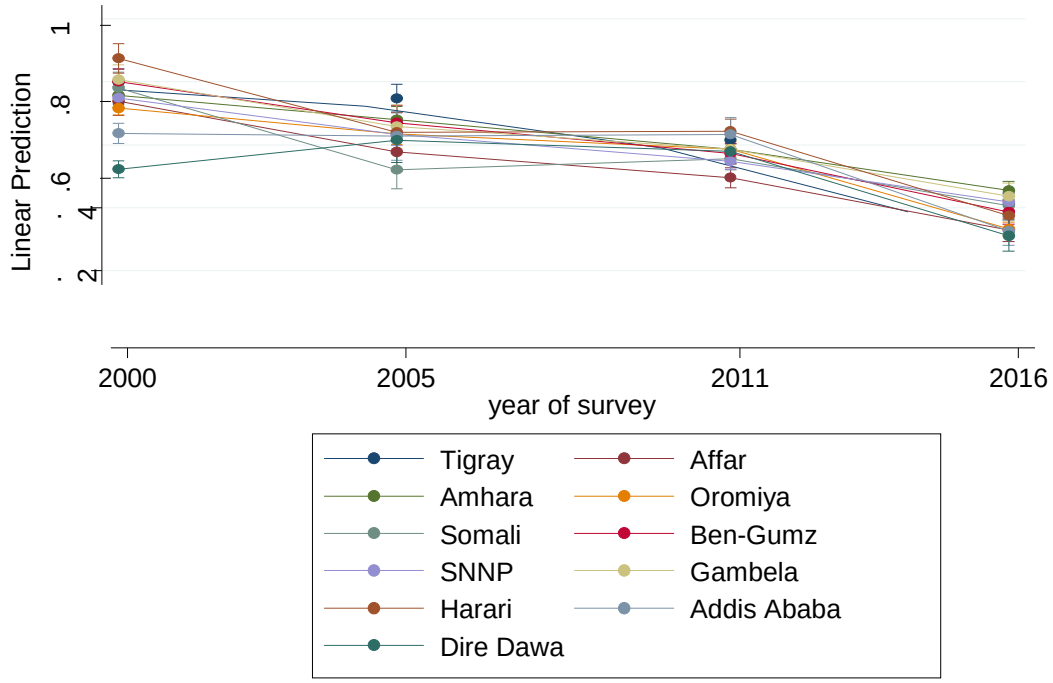

Figure 1: Profile Plot of Stunting Status for Regions

The plot in Fig.2 revealed that stunting seems declining in rural and urban areas with the exception of increasing stunting in the survey year of 2011 for urban residents. Between 2000 and 2005, child stunting seemed higher in rural areas as compared to urban areas. In the 2016 survey year, similar stunting status was observed in the rural and urban areas. The profile plot for place of residence is not parallel (p=0.0000) implying is an interaction between them (see Figure 2).

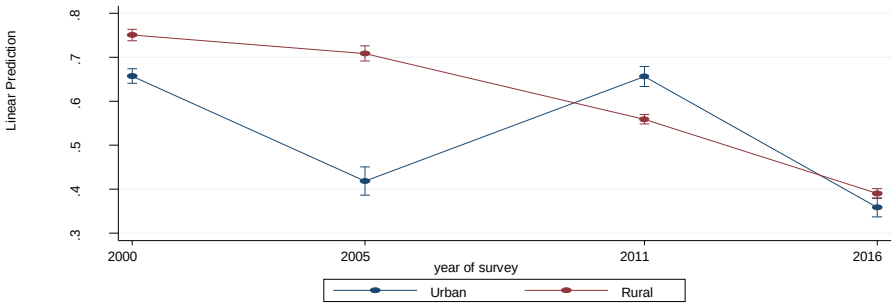

Figure 2: Profile Plot of Stunting Status for Place of Residence

In terms of sex of a child the plot shows that the profiles look parallel (p=0.06842) in child stunting. Stunting seems higher for male child.

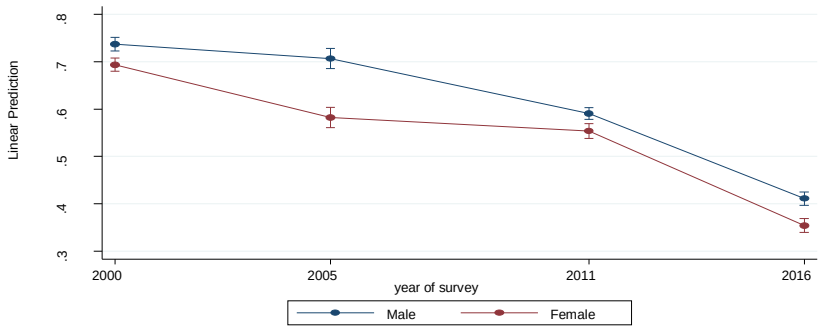

Figure 3: Profile Plot of Stunting Status for Sex of a Child

4.3 Profile Analysis of Stunting Status From 2000 to 2016 survey years

Profile analysis uses plots of the data to compare across groups. Following this, specific equations can be used to test for the significance of the various patterns or effects. There are three parts or tests of profile analysis: These are Test of Parallelism, Test of Levels (Separation) and Test of Flatness. Test of the parallelism is the test that each of the segments of the profiles is pairwise parallel. This test is the primary question addressed by profile analysis. If profiles are pairwise parallel then test whether the profiles of the groups are separated (levels). If profiles are parallel and not separated then test whether the profiles are flat, that is, the levels are the same across variables.

Test of Parallelism for the Group Region

Test parallelism was done the by transforming the response variables by using the transformation matrix. The transformation was used to perform parallelism test i.e. to test the null hypothesis $H_0 = \begin{bmatrix} \mu_{1-}\mu_2 \\ \mu_{2-}\mu_3 \\ \vdots \\ \mu_{P-1-}\mu_P \end{bmatrix} = \begin{pmatrix} 0 \\ 0 \\ \vdots \\ 0 \end{pmatrix}$. From this we can drive a contrast matrix $C=\begin{pmatrix} 1 & -1 & 0 & \cdots & 0 \\ \vdots & & \ddots & & \vdots \\ 0 & 0 & 0 & \cdots & 1-1 \end{pmatrix}$ which is used for transforming the response variable. We used Wilk's Lambda as the statistic to test the null hypothesis (the groups are parallel). For our case, F

= 1.86 (Wilk's Lambda = 0.9856) has p-value = 0.0028. Results are statistically significant (p=0.0028); therefore profiles were not parallel in terms group regions implied that there were an interaction between regions. Since the profiles were not parallel for regions, test of flatness and levels (separated) are irrelevant (see Table 4.2).

Table 4.2: Test of Parallelism for Region

Source	Statistic	df	F(df1,	df2) =	F	Prob>F
Region						
W	0.9856	10	30.0	11280.6	1.86	0.0028 a
P	0.0145		30.0	11535.0	1.86	0.0029 a
L	0.0146		30.0	11525.0	1.87	0.0028 a
R	0.0096		10.0	3845.0	3.69	0.0001 u
Residual		3845				

e = exact, a = approximate, u = upper bound on F

4.4 Determinants of Stunting among Under-five Children***:* Results of Logistic Regression Analysis**

Multiple logistic regression model was fitted to assess the effect of each selected variable on the children stunting, while controlling for other independent variables. The model was fitted to identify the basic demographic, socio-economic, and health and environmental determinants of stunting in under-five children for the four Ethiopian Demographic and Health surveys (2000-2016).

The multiple logistic regression coefficients were estimated using maximum likelihood estimation method. The estimated coefficients of variables, $\hat{\beta}$, the standard errors of estimates S.E($\hat{\beta}$), Wald statistic, degree of freedom, significance, the odds ratio(Exp($\hat{\beta}$)) and 95% Confidence interval for each predictor variables in the model are presented in Table 4.3(for 2016 year of survey, and Tables for rest of surveys are in Appendix A . The results from Binary logistic regression analysis revealed that all variables included in the model were significant predictors of child stunting status at 5% level of significance for the 2011 and 2016 survey years. For 2000 survey year, all are significant except had fever in last two weeks before survey.

Marital status, birth order of a child and had cough in last two weeks before survey are found to be not significant for the 2005 survey year indicating that the determinants of child stunting were not consistent over time.

The multiple binary logistic regression model fit results in Table 4.3 shows that children in Amhara region were 80.8% more likely to be stunted than Children in Tigray region. Similarly, children in Somali, Benishangul, SNNPR and Harari regions were 56.2%, 42.1%, 53% and 48.1 % more likely to be stunted compared to children in Tigray region respectively.

Another finding of this study indicates that place of residence is significantly associated with stunting status of a child. Particularly, rural children were 27.6% more likely to be stunted as compared to urban place of residence. In addition to this female children were 22.6% times less likely to be stunted than male.

Parental education level is associated with child's stunting status. Children whose parents had higher education level were 85% times less likely to be stunted whereas children whose parents had primary education level were 20.7% more likely to be stunted as compared to children whose parents had no education level.

In terms of source of drinking water, children whose sources of drinking water were pipe in plot and tube well water are 78.3% and 88.4% more likely to be stunted as compared to children whose source of drinking water was piped water. In addition to this, children whose family had ten and above children were 9.7% more likely to be stunted than the children whose family had one to four number of children.

The results also revealed that current contraceptive method is significantly associated with stunting status of a child. Accordingly, children whose parents were used males condom, periodic abstinence and standard day method are 44.1%, 67.5% and 87.7% less likely to be stunted than children whose parents were not used contraceptive method whereas children whose parents were used female sterilization and other method were 97.6% and 81.4% more likely to be stunted than children whose parents were not used contraceptive method. Children whose parents occupation were clerical, sales, agricultural self-employee, Household and domestic and skilled manual were 44.7%, 18.7%, 52.3%, 61.8% and 45.8% less likely to be stunted as compared to child whose parents were not working.

Children in age group 6-11 months, 12-23 months, 24-35months, 36-47 months and 48-59 months were 80.7%, 76.7%, 83.5%, 99.2% and 68.3% less likely to be stunted as compared to children in less than 6months age group respectively (see Table 4.3). Similar findings for the 2000, 2005 and 2011 surveys are presented in Appendix A.

Table 4.3: Binary Logistic Regression Analysis Result for 2016 Survey Year

Predictor variables	$\hat{\beta}$	S.E.	Wald	Df	p-value	Exp($\hat{\beta}$)	95% C.I.for EXP($\hat{\beta}$)	
							Lower	Upper
Region			**69.669**	**10**	**.000***			
Tigray (ref)								
Afar	-.096	.137	.491	1	.484	.908	.694	1.188
Amhara	.592	.124	22.716	1	.000*	1.808	1.417	2.307
Oromia	.135	.116	1.351	1	.245	1.145	.912	1.437
Somali	.446	.130	11.687	1	.001*	1.562	1.210	2.018
Benishangul	.351	.142	6.102	1	.013*	1.421	1.075	1.878
SNNPR	.425	.127	11.152	1	.001*	1.530	1.192	1.964
Gambela	.563	.153	13.588	1	.000*	1.756	1.302	2.368
Harari	.393	.153	6.623	1	.010*	1.481	1.098	1.998
Addis Ababa	.046	.174	.071	1	.790	.047	.745	1.472
Dire Dawa	-.101	.164	.374	1	.541	.904	.655	1.248
Place of residence			**9.275**	**1**	**.002***			
Urban (ref)								
Rural	.244	.080	9.275	1	.002*	1.276	1.091	1.493
Parental education level			**200.596**	**3**	**.000***			
No education (ref)								
Primary	.188	.064	8.521	1	.004*	1.207	1.064	1.369
Secondary	-.281	.111	6.391	1	.011*	.755	.607	.939
Higher	-1.898	.145	170.377	1	.000*	.150	.113	.199
Source of drinking water			**96.377**	**18**	**.000***			
Piped water(ref)								
Piped into dwelling	.736	.397	3.445	1	.063	2.088	.960	4.542
Piped in yard/plot	1.023	.361	8.042	1	.005*	2.783	1.372	5.645
Piped into neighbor	.496	.371	1.785	1	.182	1.642	.793	3.397
Public tab/stand pipe	.674	.360	3.509	1	.061	1.962	.969	3.973
Tube well water	2.184	.552	15.685	1	.000*	8.884	3.014	26.186
Dug well (open/protected)	.295	.523	.317	1	.573	1.343	.482	3.743
Protected well	.127	.361	.124	1	.725	1.135	.559	2.304
Unprotected well	.238	.369	.416	1	.519	1.269	.615	2.617
Surface water	.245	.401	.373	1	.541	1.277	.583	2.801
Protected spring	.382	.365	1.093	1	.296	1.465	.716	2.997
Unprotected spring	.994	.398	6.241	1	.012*	2.703	1.239	5.898
River/dam/lake/pond/stream/canal/ irrigation channel	.947	.383	6.096	1	.014*	2.577	1.216	5.463
Rain water	.099	.390	.065	1	.799	1.104	.514	2.370
Tanker truck	.678	.402	2.854	1	.091	1.971	.897	4.330
Cart with small tank	.899	.494	3.316	1	.069	2.458	.934	6.470
Bottled water	.850	.414	4.211	1	.040*	2.340	1.039	5.270
Other	.900	.429	4.401	1	.036*	2.461	1.061	5.706
Not dejure resident	1.799	.464	15.013	1	.000*	6.044	2.433	15.017
Number of living children in family			**20.203**	**2**	**.000***			
1-4(ref)								
5-9	.118	.077	2.363	1	.124	1.125	.968	1.307

10 and above	.741	.166	19.787	1	.000*	2.097	1.513	2.906
Current contraceptive method			**237.036**	**13**	**.000***			
Not using (ref)								
Pill	-.281	.178	2.501	1	.114	.755	.533	1.070
IUD	-.308	.205	2.262	1	.133	.735	.492	1.098
Injections	-.030	.076	.153	1	.696	.971	.837	1.126
Males condom	-.581	.194	8.980	1	.003*	.559	.383	.818
Diaphragm	.100	.226	.194	1	.660	1.105	.709	1.721
Female sterilization	1.942	.301	41.730	1	.000*	6.976	3.869	12.576
Male sterilization	.275	.160	2.933	1	.087	1.316	.961	1.802
Periodic abstinence	-1.124	.524	4.597	1	.032*	.325	.116	.908
Withdrawal	1.146	1.209	.898	1	.343	3.144	.294	33.609
Other	1.760	.139	160.425	1	.000*	5.814	4.427	7.634
Implant/Norplant	.112	.112	.996	1	.318	1.119	.898	1.394
lactational amenorrhea	-.830	.595	1.946	1	.163	.436	.136	1.399
Standard day method	-2.092	.601	12.105	1	.001*	.123	.038	.401
Current marital status of mothers			**40.819**	**5**	**.000***			
Never in union (ref)								
Married	.823	.170	23.407	1	.000*	2.277	1.632	3.178
Living with partner	.903	.524	2.969	1	.085	2.467	.883	6.892
Widowed	.799	.283	7.989	1	.005*	2.223	1.278	3.869
Divorced	1.339	.230	33.777	1	.000*	3.817	2.430	5.996
Not living with partner/separated	3.048	.910	11.222	1	.001*	21.077	3.542	125.409
Parental occupation			**49.318**	**10**	**.000***			
Not working(ref)								
Professional/technical manager	.206	.161	1.644	1	.200	1.229	.897	1.684
Clerical	-.592	.133	19.845	1	.000*	.553	.426	.718
Sales	-.207	.100	4.298	1	.038*	.813	.668	.989
Agric-self employee	-.740	.225	10.816	1	.001*	.477	.307	.742
Agricultural employee	-.115	.140	.672	1	.412	.892	.678	1.173
Household and domestic	-.961	.195	24.276	1	.000*	.382	.261	.561
Services	.005	.303	.000	1	.986	1.005	.556	1.819
Skilled manual	-.612	.189	10.520	1	.001*	.542	.375	.785
Unskilled manual	-.070	.189	.137	1	.712	.933	.644	1.350
Other	.335	.463	.525	1	.469	1.398	.564	3.465
Birth order number			**372.176**	**3**	**.000***			
1(ref)								
2-3	1.237	.128	93.520	1	.000*	3.446	2.682	4.428
4-5	.883	.168	27.519	1	.000*	2.418	1.739	3.364
6+	3.875	.223	301.107	1	.000*	48.187	31.106	74.647
Sex of a child			**34.722**	**1**	**.000***			
Male (ref)								
Female	-.296	.050	34.722	1	.000*	.744	.674	.821
Had fever in last two weeks before survey			**35.078**	**2**	**.000***			
No (ref)								
Yes	-.433	.081	28.659	1	.000*	.648	.553	.760
Don't know	-.469	.160	8.563	1	.003*	.625	.457	.856
Had cough in last two weeks before survey			**25.683**	**3**	**.000***			
No (ref)								
Yes, last 24 hours	-2.282	.932	5.994	1	.014*	.102	.016	.634
Yes, last two weeks	.315	.072	19.001	1	.000*	1.370	1.189	1.578
Don't know	.094	.194	.233	1	.630	1.098	.751	1.606
Age of a child			**599.035**	**5**	**.000***			
<6months (ref)								
6-11months	-1.646	.125	172.574	1	.000*	.193	.151	.246
12-23months	-1.455	.145	101.271	1	.000*	.233	.176	.310

24-35months	-1.804	.199	82.104	1	.000*	.165	.111	.243
36-47months	-4.856	.216	506.117	1	.000*	.008	.005	.012
48-59months	-1.148	.122	88.431	1	.000*	.317	.250	.403
Constant	-1.555	.420	13.703	1	.000*	.211		

4.5. Goodness of Fit and Model Diagnostics for Logistic Regression

Goodness of fit

After fitting a regression model, it is necessary to test the adequacy of the model. Hence, we performed a global test of the goodness of fit of our logistic regression model.

4.5.1 Likelihood Ratio Test

The most common assessment of overall model fit in logistic regression is the likelihood ratio test. This statistic measures how poorly the model predicts the stunting among children under-five years age; the smaller value of the statistic the better the model.

From Table 4.4, the -2 log likelihood value for the null model and final model were 10230.496 and 8221.235 respectively. To test the null model over the final model, the difference in -2 log likelihood has a chi-square distribution with 76 degrees of freedom has a value of 2009.261 and p-value less than 0.05. This shows that the final model has a good fit which indicates that the predictor variables were important in predicting the stunting status of a child for the 2016 survey years (Table 4.4). Similarly, the final model has a good fit for the 2000, 2005 and 2011 surveys (see Appendix A).

Table 4.4: Summary Statistics of the Likelihood Ratio Test for 2016 Survey Year

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	Df	Sig.
Null model	10230.496			
Final model	8221.235	2009.262	76	.000

4.5.2 Hosmer and Lemeshow Goodness of fit Test

The Hosmer-Lemeshow goodness of fit test divides subjects into g classes (often deciles) based on predicted probabilities and then computes a chi-square from observed and expected frequencies. A non-significant chi-square implies that there is no significant difference between the observed and the model predicted values and hence the estimated model adequately fit the data. Since the p-value for all survey year was greater than 0.05, we do not reject the null

hypothesis that there is no difference between observed and model-predicted values, implying that the estimated model fits the data at an acceptable level (see Table 4.5 for the 2016 survey). The result of the rest survey year appeared on Appendix A.

Table 4.5: Hosmer and Lemeshow Test for 2016 Survey Year

Step	Chi-square	Df	Sig.
1	6.678	8	0.572

4.5.3 Influential and outliers Diagnostics

The adequacy of the fitted model was checked for possible presence and treatment of outliers and influential values for all survey years. The diagnostic test results for detection of outliers and influential values are presented in the Appendix B. The DFBETAs for the model parameters including the constant term and Cook's influence statistic were both less than unity. DFBETAs less than unity imply that there is no specific impact of an observation on the coefficient of a particular predictor variable. Cook's distance less than unity shows that an observation had no overall impact on estimated vector of regression coefficient. A value of the leverage statistic less than one shows that no subject has a substantial large impact on the predicted values of the model. Thus, from the above goodness of fit tests and diagnostic checking results, we can say that our model is adequate for all survey years (see Appendix A).

4.6 Multilevel Binary Logistic Regression Analysis

In the multilevel analysis, a two-level structure was used with regions as the second-level units and individual children as first level units. Our analysis was mainly aimed at comparison between regions and within regions variation of stunting among children under-five age in Ethiopia. The hierarchical structure of the data was formed such that individual children were nested in the 11 geographical regions based on 2000-2016 Ethiopian Demographic and Health Survey.

4.6.1 Test of Heterogeneity

Before analyzing the data using multilevel approach, there is a need to check for the heterogeneity of stunting status among under-five children with regard to regions. Before analyzing the data using multilevel approach, there is a need to check for the heterogeneity of stunting status among under-five children with regard to regions. The chi-square test was applied to assess heterogeneity between regions means. The test results are $\chi 2 = 81.633$ with d.f = 10

(p=0.000). Thus, there is evidence of heterogeneity with respect to the child stunting among the regions of Ethiopia for 2016 year of survey.

4.6.2 Empty (Null) Multilevel Logistic Regression Model

In this model we first fit a simple model with no predictors i.e. an intercept-only model that predicts the probability of child stunting status. The simplest specification of the hierarchical linear model is a model in which only the intercept varies between level two units and no predictor variables are entered in the model. The empty model contains no explanatory variables and it can be considered as a parametric version of assessing heterogeneity among regions with respect to stunting status. It is the model that incorporates only the grand mean and random intercept (regional effect) without covariate. It is given by:

logit (p_j) =$\beta 0 + u_{0j}$, where u_{0j}, ~IID $(0, \sigma_0^2)$.

The intercept, $\beta_{0,}$ also known as the grand mean is shared by all regions while the random effect $u_{0j,}$ also known as level two residual is specific to region j. It shows how the mean in a particular region deviates from the grand mean. σ_0^2 is the between regions variance. The random effect is not directly estimated but is summarized in terms of their estimated variances.

Presented in Table 4.6 are the estimates of fixed effects and random effects. The fixed part of the model is interpreted as the grand mean of log odds of child stunting with odds exp (-.484) = 0.6163. The average probability of the child stunting is $\frac{\exp(-.484)}{1+\exp(-.484)}$ =0.3813.

The Table also contains the variance estimate of the random effects at regional level, σ_0^2= 0.0336 which is the between-region variance of child stunting for 2016 survey year. The variation is high for 2000 survey year, var(cons)= σ_0^2 = 0.2042 and approximately similar for 2005 and 2011 survey years (refer to Appendix B). The variance of the random factor in empty model is significant which indicates that there are regional differences in the child stunting. This evidence was true for all survey years.

Using the results in Table 4.6, we calculated ICC, which measure the correlation between two individuals who are in the same higher level unit (region). A low ICC indicates a relatively small between region variations. As ICC increases, regions tend to perform with ever increasing variations to reduce the child stunting.

According to (Snijders and Bosker, 1999) the individual (level-one) variance was fixed to $\pi^2/3$ which is 3.29 for logit model. In order to get an idea of how much of variation in stunting among

children under-five age years was attributable to the region level factors, it is useful to see the intra-region correlation coefficient (ICC)= 0.0336/1+3.29= 0.0078 (for 2016 survey year), which measures the proportion of variance of the child stunting that is between regions, not within regions. The intra-region correlation coefficient (ICC) in intercept only model is 0.0078. This means that around 0.78% of the variance in child stunting is due to variation across (between) regions. Whereas the remaining 99.22% is attributable to individual level, that is within region differences for 2016 survey years. ICC was 0.0478, 0.0104 and 0.0094 for 2000, 2005 and 2011 survey years respectively.

Table 4.6: Random intercept only model fit results for 2016 Survey Year

stuntstatus	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
_cons	-.4847	.0605	-8.01	0.000	-.6033	-.3661

Random-effects Parameters	Estimate	Std. Err.	P-value	[95% Conf. Interval]	
-region: Identity					
var(_cons)	.0336	.0172	0.0251	.0123	.0916

LR test vs. logistic regression: chibar2(01) = 48.75 Prob>=chibar2 = 0.0000

Model	Obs	LL value	df	AIC	BIC
M0	8703	-5768.9	2	11541.8	11555.94

4.6.3 Result of Random Intercept and Fixed Effect Multilevel Analysis

In a random intercept and fixed coefficient multilevel logistic regression model, we allow the probability of child stunting to vary across regions assuming that the effects of the explanatory variables are the same for each region. That is, the random intercept varies across regions, but children level explanatory variables are fixed across regions.

Table 4.7 provides estimates of the fixed slopes and associated odds ratios. Values of the Wald test statistic used for testing the significance of individual predictors are also given with the corresponding p-values. The overall goodness of fit test results, Wald chi-square (66) = 1207.39 with p =0.000 indicate that all explanatory variables jointly are significant.

The deviance of the random intercept model, 11537.8 is reduced to 9616.806 when we included covariates for the same random intercept with fixed slope which implies that the random intercept with fixed slope model is better than the random intercept only model. The BIC and AIC values of empty level model were smaller as compared to the AIC and BIC values for random intercept model which implies random intercept model is a better model was the better model.

Table 4.7: Result of Random Intercept Multilevel Analysis for 2016 survey year

Variables	Coef.	Std. Err.	Z	P>z	OR	[95% Conf. Interval] for OR	
						Upper	Lower
Place of res							
Urban(ref)							
Rural	.2446	.07975	3.07	0.002	1.2771	1.092	1.493
Educ level							
No education(ref)							
Primary	.1893	.0641	2.95	0.003	1.2084	1.065	1.3704
Secondary	-.2775	.1109	-2.50	0.012	.7576	.6095	.9416
Higher	-1.9181	.1459	-13.14	0.000	.14687	.1103	.1955
Source of dwater							
Piped water(ref)							
Piped into dwelling	.7723	.3957	1.95	0.051	2.1648	. 9966	4.7023
Piped into yard/plot	1.0338	.3596	2.87	0.004	2.8118	1.389	5.690
Piped into neighbor	.5120	.3699	1.38	0.166	1.6686	.808	3.445
Public tab	.6567	.3586	1.83	0.067	1.9284	.9547	3.894
Tube well	2.151	.5494	3.92	0.000	8.6	2.9296	25.245
Dug well	.3569336	.5207	0.69	0.493	1.4289	.5149	3.965
Protected well	.1599	.3601	0.44	0.657	1.1733	.5793	2.3767
Unprotected well	.254	.3681	0.69	0.489	1.2899	.626	2.654
Surface water	.2822	.398	0.71	0.479	1.3261	.6068	2.897
Protected spring	.4083	.3641	1.12	0.262	1.5043	.7368	3.071
Unprotected spring	.9793	.3960	2.47	0.013	2.6626	1.225	5.7868
Lake/dam/pond/stream	.9254	.381	2.43	0.015	2.5230	1.195	5.3255
Rain water	.1348	.3889	0.35	0.729	1.1444	.5339	2.4525
Tanker truck	.749	.4001	1.87	0.061	2.1157	.9657	4.6349
Cart with small tank	.9477	.492	1.92	0.054	2.5799	.982	6.777
Bottled water	.8673	.4128	2.10	0.036	2.3806	1.059	5.3473
Other	.9039	.4282	2.11	0.035	2.4693	1.0667	5.716
Not dejure resident	1.726	.4630	3.73	0.000	5.6217	2.268	13.932
Number of living chil							
1-4(ref)							
5-9	.1171	.076	1.53	0.126	1.1242	.9677	2.9045
10 and above	.7405	.1662	4.46	0.000	2.0970	1.513	1.3060
Contraceptive method							
Not using(ref)							
Pill	-.2827	.1773	-1.59	0.111	.7536	.5323	1.066
IUD	-.3056	.2047	-1.49	0.135	.7366	.4931	1.1003
Injections	-.0209	.0757	-0.28	0.782	.9792	.8441	1.1359
Male condom	-.5981	.1915	-3.12	0.002	.5498	.3777	.8002
Diaphragm	.1023	.2257	0.45	0.650	1.1077	.7116	1.724
Female sterilization	1.951	.3011	6.48	0.000	7.0391	3.9010	12.701
Male sterilization	.278	.1601	1.74	0.082	1.3213	.9652	1.808
Periodic abstinence	-1.138	.5244	-2.17	0.030	.3202	.1145	.8952

Withdrawal	1.139	1.211	0.94	0.347	3.1262	.291	33.573
Other	1.773	.1392	12.74	0.000	5.8925	4.48	7.7412
Norplant	.11486	.1121	1.02	0.306	1.1217	.9004	1.397
Lactational amenorrhea	-.8479	.5941	-1.43	0.154	.4283	.1336	1.3725
Standard day method	-2.079	.6007	-3.46	0.001	.1249	.0384	.4055
Marital status							
Never in union (ref)							
Married	.8066	.1691	4.77	0.000	2.2403	1.6080	3.121
Living with partner	.8712	.523	1.66	0.096	2.3898	.856	6.669
Widowed	.7963	.2815	2.83	0.005	2.2173	1.276	3.8504
Divorced	1.322	.2295	5.76	0.000	3.7533	2.3936	5.885
Not living with partner	3.016	.9111	3.31	0.001	20.41818	3.423	121.780
Parental occupation							
Not working(ref)							
Prof., tech., managerial	.1693	.1595	1.06	0.288	1.1845	.8664	1.6193
Clerical	-.5473	.1322	-4.14	0.000	.5785	.446	.7496
Sales	-.2123	.0991	-2.14	0.032	.8086	.665	.9821
Agric-self employee	-.7011	.2232	-3.14	0.002	.4960	.3201	.7683
Agric-employee	-.1120	.1393	-0.80	0.421	.8940	.6803	1.1748
HH and domestic	-.919	.1931	-4.76	0.000	.3986	.2730	.5820
Services	-.0276	.3021	-0.09	0.927	.9726	.5379	1.7587
Skilled manual	-.6249	.1880	-3.32	0.001	.5352	.3702	.7738
Unskilled manual	-.0509	.1882	-0.27	0.787	.9503	.6570	1.374
Other	.2725	.4579	0.60	0.552	1.313	.535	3.222
Birth order							
1(ref)							
2-3	1.215	.1275	9.53	0.000	3.372	2.626	4.330
4-5	.8575	.1673	5.12	0.000	2.357	1.698	3.272
6+	3.8014	.2196	17.31	0.000	44.765	29.1064	68.847
Sex							
Male(ref)							
Female	-.2961	.0501	-5.90	0.000	.74366	.6740	.8205
Fever							
No(ref)							
Yes	-.4344	.0808	-5.37	0.000	.64759	.5526	.7588
Don't know	-.4602	.1597	-2.88	0.004	.6311	.461	.8630
Cough							
No(ref)							
Yes, last 24 hours	-2.3077	.9333	-2.47	0.013	.09948	.0159	.6197
Yes, last weeks	.308	.0720	4.29	0.000	1.3618	1.182	1.568
Don't know	.0642	.1929	0.33	0.739	1.066	.7306	1.556
Age of a child							
<6months(ref)							
6-11months	-1.647	.1249	-13.19	0.000	.1925	.1507	.2459
12-23months	-1.453	.1439	-10.10	0.000	.2337	.1763	.3099
24-35months	-1.784	.1974	-9.04	0.000	.1678	.113	.2471
36-47months	-4.804	.2126	-22.60	0.000	.008	.005	.0124
48-59months	-1.1733	.1219	-9.63	0.000	.3093	.243	.3928
_cons	-1.2754	.4122	-3.09	0.002	.2793	.1245	.6266
Random-effects Parameters | Estimate Std. Err. [95% Conf. Interval]							
region: Identity							
var(_cons) .04739 .0250941 .0167863 .1337882							
LR test vs. logistic regression: chibar2(01) = 37.62 Prob>=chibar2 = 0.0000							

Model	Obs	LL value	df	AIC	BIC
M1	8703	-4808.403	68	9752.807	10233.66

4.6.4 Result of Random Coefficient Multilevel Analysis

It is possible to generalize the model so that the effect of level-1 covariates is different in each region. In random intercept model we allowed the intercept to vary across regions by fixing explanatory covariates, but the relation between explanatory and dependent variables can differ between groups (regions in our case). This model contains a random slope for age of child, which means that it allows the effect of the coefficient of this variable to vary from region to region. This model is more appropriate than the previous model for the variables being used since it is intuitive to assume that age of a child varies from region to region.

In Table 4.8, the value of Var (age) and Var (cons) are the estimated variance of intercept and slope of age respectively. In each model, by adding level-1 predictors, the ICC increased and estimated as 0.0088+0.2555/0.0088+0.2555+3.29= 0.0743 meaning that roughly 7.43 % of the total variability in child stunting is attributable to the random factor and region in random coefficient multilevel binary logistic model. From the Table again the random coefficient estimates for intercepts and the slopes vary significantly since its the confidence interval does not include zero, which implies that there is a considerable variation in the effects of age of child and this variables differ significantly across the regions.

The deviance-based Chi-square value of 62.72, prob >chi-square = 0.0000, is the difference between the model with and without random effects models. The significance of this difference further indicates that a model with a random coefficient is more appropriate to explain regional variation than a model with fixed coefficients.

Table 4.8: Result of Random Coefficient Multilevel Analysis for the 2016 survey

Variables	Coef.	Std.Err.	Z	P>z	OR	[95%Conf. Interval]for OR	
						Lower	Upper
Place of residence							
Urban(ref)							
Rural	.2806	.0807	3.48	0.001	1.23	1.1302	1.5508
Parental education							
No education (ref)							
Primary	.2098	.0646	3.25	0.001	1.233	1.086	1.400
Secondary	-.3056	.1120	-2.73	0.006	.7366	.5913	.9175
Higher	-1.949	.1466	-13.29	0.000	.1424	.1068	.189
Source of drinking water							
Piped water(ref)							
Piped into dwelling	1.001	.3586	2.79	0.005	2.72	1.3483	5.499
Piped into yard/plot	.4645	.369	1.26	0.208	1.59	.77179	3.2807
Piped into neighbor	.5892	.3575	1.65	0.099	1.80	.8943	3.6331
Public tab	1.959	.5485	3.57	0.000	7.093	2.4207	20.789
Tube well	.2646	.532	0.50	0.619	1.30	.4590	3.698
Dug well	.0960	.3590	0.27	0.789	1.100	.5446	2.224
Protected well	.2171	.3673	0.59	0.554	1.242	.6048	2.552
Unprotected well	.3053	.398	0.77	0.444	1.3570	.6212	2.9645
Surface water	.3602	.3631	0.99	0.321	1.433	.70363	2.9213
Protected spring	.9105	.3943	2.31	0.021	2.485	1.1476	5.383
Unprotected spring	.9150	.380	2.40	0.016	2.496	1.1842	5.2643
Lake/dam/pond/stream	.0456	.3893	0.12	0.907	1.046	.48796	2.2452
Rain water	.7209	.4009	1.80	0.072	2.056	.93717	4.512
Tanker truck	.9347	.4934	1.89	0.058	2.546	.9681	6.698
Cart with small tank	.840	.4125	2.04	0.042	2.317	1.032	5.2027
Bottled water	.8372	.4285	1.95	0.051	2.309	.99727	5.3505
Other	1.7118	.4643	3.69	0.000	5.539	2.229	13.764
Number of children							
1-4(ref)							
5-9	.1173	.0766	1.53	0.126	1.124	1.3067	.96768
10 and above	.7098	.166	4.26	0.000	2.033	2.818	1.4672
Contraceptive method							
Not using(ref)							
Pill	-.2845	.178	-1.59	0.111	.7523	.53017	1.0676
IUD	-.3156	.2058	-1.53	0.125	.7292	.48716	1.0917
Injections	-.0167	.0762	-0.22	0.826	.9833	.84680	1.1419
Male condom	-.6504	.1910	-3.40	0.001	.5217	.35879	.7588
Diaphragm	.0695	.2260	0.31	0.758	1.072	.6883	1.6695
Female sterilization	1.989	.3026	6.57	0.000	7.308	4.0382	13.225

Male sterilization	.2417	.1609	1.50	0.133	1.273	.9289	1.745
Periodic abstinence	-1.133	.5267	-2.15	0.031	.3218	.11463	.90376
Withdrawal	1.099	1.201	0.92	0.360	3.002	.28521	31.608
Other	1.809	.1396	12.96	0.000	6.105	4.6438	8.027
Norplant	.1115	.112	0.99	0.322	1.118	.8966	1.3939
Lactational amenorrhea	-.8042	.5940	-1.35	0.176	.447	.1396	1.433
Standard day method	-2.062	.6003	-3.44	0.001	.1271	.0391	.4122
Marital status							
Never in union (ref)							
Married	.7904	.1698	4.65	0.000	2.2043	1.5802	3.0749
Living with partner	.8359	.5216	1.60	0.109	2.307	.8299234	6.413
Widowed	.789	.2841	2.78	0.005	2.203	1.2623	3.844
Divorced	1.331	.2299	5.79	0.000	3.785	2.411943	5.941
Not living with partner	3.044	.9090	3.35	0.001	21.00	3.5358	124.7
Parental occupation							
Not working(ref)							
Prof., tech., managerial	.1469	.1608	0.91	0.361	1.1583	.8450	1.5876
Clerical	-.5360	.13169	-4.07	0.000	.5850	.4519	.7573
Sales	-.2276	.0992	-2.29	0.022	.7963	.6556	.9673
Agric-self employee	-.681	.2221	-3.07	0.002	.5056	.3271	.781
Agric-employee	-.1524	.14022	-1.09	0.277	.8586	.6522	1.130
HH and domestic	-.9584	.1942	-4.94	0.000	.3834	.26207	.5610
Services	-.0329	.3026	-0.11	0.913	.9676	.5346	1.751
Skilled manual	-.6644	.1907	-3.48	0.000	.5145	.354	.7477
Unskilled manual	-.0933	.189	-0.49	0.623	.9108	.6280	1.321
Other	.2132	.4610	0.46	0.644	1.237	.5014	3.055

Birth order							
1(ref)							
2-3	1.289	.129	9.95	0.000	3.630	2.8162	4.680
4-5	.9320	.1697	5.49	0.000	2.53	1.8208	3.542
6+	3.907	.221	17.64	0.000	49.75	32.229	76.80
Sex of a child							
Male(ref)							
Female	-.2944	.0503	-5.85	0.000	.744	.6750	.8221
fever							
No (ref)							
Yes	-.4322	.0811	-5.33	0.000	.6490	.5536	.7609
Don't know	-.4552	.1607	-2.83	0.005	.6342	.4628	.8690
cough							
No (ref)							
Yes, last 24 hours	-2.413	.9307	-2.59	0.010	.0895	.014	.5547
Yes, last weeks	.3071	.0723	4.25	0.000	1.359	1.179	1.566
Don't know	.065	.193	0.34	0.733	1.068	.7315	1.559
age of a child							
<6months							
6-11months	-1.601	.1294	-12.37	0.000	.2015	.1563	.25972
12-23months	-1.398	.1571	-8.89	0.000	.2470	.18154	.33619
24-35months	-1.732	.2178	-7.95	0.000	.1767	.1153	.27091
36-47months	-4.755	.2445	-19.45	0.000	.0086	.0053	.0138
48-59months	-1.03	.1946	-5.30	0.000	.3564	.2434	.52196
_cons	-1.362	.4279	-3.18	0.001	.2560		

Random-effects Parameters	Estimate	Std. Err.	[95% Conf. Interval]	
var(age)	.008836	.0050826	.0028617	.0272821
var(_cons)	.2555567	.1286339	.0952877	.68539
cov(age, cons)	-.0463037	.0249046	-.0951159	.0025084

LR test vs. logistic regression: chi2(3) = 62.72 Prob > chi2 = 0.0000

Model	Obs	LL value	df	AIC	BIC
M0	8703	-4795.856	70	9731.712	10226.71

4.6.5 Model Comparison

The choice of relevant multilevel model is an important step, and it should on the necessity of parsimony in the model which means that models should be as simple as possible. The choice of relevant multilevel model is an important step, and it should be based on the necessity of parsimony in the model which means that models should be as simple as possible (Hox, 2010).

Table 4.9: Model Comparison

	Null model	Random intercept model	Random coefficient model
Log likelihood	-5768.9	-4808.403	-4795.856
Deviance	11537.8	9616.806	9591.712
AIC	11541.8	9752.807	9731.712
BIC	11555.94	10233.66	10226.71

The quantity AIC and BIC can be used to make an overall comparison of model with the three models. As shown in Table 4.15, values of AIC and BIC for the random coefficient model are the smallest. This indicates that the random coefficient model is a better fit compared to the random intercept and fixed effect model. The parameters of observed variables can be interpreted in much the same way as those from the standard logit model. Rural children were 23% more likely to be stunted as compared to urban children. In addition to this, children whose parents had secondary and higher education level were 26.34% and 85.76% less likely to be stunted where as children whose parents had primary education level were 23.3% times more likely to be stunted as compared to the children whose parents had no education level controlling for other variables in the model and random effects at level two.

Similarly, children whose sources of drinking water are piped into dwelling, public tab, unprotected spring and other source of drinking water were 72%, 9.3%, 49.6% and 53.9% more likely to be stunted than children whose drinking water is piped water respectively. Additionally, children whose family had ten and above number of children in the family were 3.3% more likely to be stunted than the children whose family had only less than or equal four. Children whose parents were used contraceptive method like male condom; periodic abstinence and standard day method were 47.83%, 68.82% and 87.29% less likely to be stunted than children whose parents were not used contraceptive method respectively whereas children whose parents were used female sterilization and other method were 30.8% and 10.5% more likely to be stunted controlling for other variables in the model and random effects at level two.

Likewise, children from married women, widowed and divorced were 20.43%, 20.3% and 78.5% more likely to be stunted as compared to children from never in union respectively controlling for other variables in the model and random effects at level two.

Children from a parents whose occupation were clerical, sales, agricultural self-employee, House hold and domestic and skilled manual were 41.5%, 79.63%, 50.56%, 38.34% and 51.45% less likely to be stunted than children from not working parents respectively. Children whose birth order were 2-3, 4-5 and 6 and above were 63%, 53% and 75% more likely to be stunted as compared to children whose birth order is first controlling for other variables in the model and random effects at level two.

Female children were 25.6% times less likely to be stunted as compared male children controlling for other variables in the model and random effects at level two. Similarly, children in age group 6-11 months, 12-32 months, 24-35 months, 36-47 months and 48-59 months were 79.85%, 75.3%, 82.33%, 99.14% and 64.36% less likely to be stunted than children in less than 6 months age group respectively controlling for other variables in the model and random effects at level two.

4.7 Goodness of Fit Test

Based on the result we obtained in Table 4.9 (random coefficient model), the deviance chi-square is significant and the values of AIC and BIC are less than the AIC and BIC values we obtained for the random intercept with fixed slope model. So, we conclude that the random coefficient model is a better fit.

5. DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

5.1 DISCUSSIONS

This study intended to identify the determinants and trends of child stunting among under-five children in Ethiopia based on evidence from the four Ethiopian Demographic and Health Survey (EDHS). Consequently, exploratory data analysis, profile analysis and multilevel logistic regression analyses were used.

Children's place of residence was found to be significantly associated with stunting status of a child. Children residing in rural areas were found to be more likely to be stunted than children in urban areas (EDHS reports; EDRI, 2014).

Female children were less likely to be stunted as compared to male children controlling for other variables in the model. This is in agreement with the findings in other studies (EDHS reports; EDRI, 2014; Matanda et al, 2014, Zewdie T. and Abebaw D., 2013).

Age of a child and stunting status were related positively. The majority of the stunted children were found in the age group 48-59 months. The prevalence of child stunting was highest in Tigray region and lowest in Addis Ababa and Dire dawa city administrations.

The proportion of children who were stunted declines with improving parental education. Children whose parental education level was higher were less likely to be stunted as compared to children whose parents had no education. This result is consistent with EDHS report (2016). With respect to mother's marital status, children whose mothers were married had higher chance of stunting than children whose mothers were single (never in union).

From the bivariate tests of association, results showed that stunting status of children under age five was significantly associated with socio economic, demographic, and environmental and health factors. This result was in harmony with other studies (Danbe D. and Taye A., 2011; workineh S. and Teshome B., 2016).

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

wise variations with respect to childhood stunting. Using multilevel logistic regression method of analysis, this study examined variations in childhood stunting among geographical regions. The model suggests that the status of stunting of children differs among regions, although the variations among different regions with respect to stunting were found to originate mainly from variations in individual-level factors. These findings are consistent with Ali et al., 2016. Profile plot implied that child stunting status was declined over time. This result had agreed with EDHS reports.

5.2 Conclusion

The descriptive results show that stunting status of a children declined from 71.5% in 2000 to 38.3 in 2016 in Ethiopia. Binary logistic regression analysis revealed that all variables included in the model were significant predictors of child stunting for the 2011 and 2016 survey years. For 2000 survey year, all are significant except had fever in last two weeks before survey. Marital status, birth order of a child and had cough in last two weeks before survey are found to be not significant for the 2005 survey year indicating that the determinants of child stunting were not consistent over time.

From the methodological aspect, it was found out that multilevel random coefficient model is better compared to empty (null) model and random intercept model in fitting the data and in explaining the variations of stunting status of a child across regions of Ethiopia. Profile analysis was done for regions. Accordingly, profiles were not parallel implied that there were interactions between regions.

The multilevel logistic regression results revealed that only the effect of age varied across regions whereas the effects of other covariates on child stunting remained fixed across regions.

5.3 Recommendations

In order to formulate policies to control the child stunting Ethiopia, it is important not only to understand the incidence of stunting among the children, but also how it differs with demographic and economic characteristics. In response to this challenge, this study suggests the following possible solutions to reduce child stunting more in Ethiopia.

- Policies that promote parental education, family planning, facilities like source of drinking water should be promoted.

- Any intervention by governmental and non-governmental organizations that aim at improving under-five children nutritional status should consider regions with a high rate of childhood stunting so as to avert under-coverage of the regions that deserve it.
- Further studies, should be conducted to identify other determinants and trends of stunting among under-five children to make the declining fast enough.

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APPENDIX A

Table A1: Distribution of socio-economic, demographic, health and environmental characteristics of stunting status for the 2000 survey

Variables		stunting status of a child					
		not stunted	stunted	Total			
		Count (%)	Count (%)	Count	Chi-square	df	p-value
Region	Tigray	959(20.2%)	376(79.8%)	471	366.149	10	<.0001
	Affar	108(26.1%)	306(73.9%)	414			
	Amhara	258(24.2%)	806(75.8%)	1064			
	Oromiya	521(28.3%)	1322(71.7%)	1843			
	Somali	79(21.9%)	282(78.1%)	361			
	Ben-Gumz	106(19.9%)	427(80.1%)	533			
	SNNP	253(25.1%)	753(74.9%)	1006			
	Gambela	75(19.3%)	313(80.7%)	388			
	Harari	49(12.6%))	340(87.4%)	389			
	Addis	313(47.7%)	548(52.3%)	861			
	Dire Dawa	570(36.3%)	625(63.6%)	1195			
Type of place of residence	Urban	1107(34.3%)	2122(65.7%)	3229	86.273	1	<.0001
	Rural	1320(24.9%)	3976(75.1%)	5296			
parental educational level	No education	1504(28.2%)	3837(71.8%)	5341	323.032	3	<.0001
	Primary	439(26.3%)	1230(73.7%)	1669			
	Secondary	327(24.5%)	1009(75.5%)	1336			
	Higher	157(87.7%)	22(12.3%)	179			

Source of drinking water	PIPED WATER	41(20.1%)	163(79.9%)	204	37.488	11	<.0001
	Piped into dwelling	2(20.0%)	8(80.0%)	10			
	Piped into compound	256(25.1%)	762(74.9%)	1018			
	Piped outside compound	776(27.7%)	2022(72.3%)	2798			
	WATER FROM OPEN WELL	109(27.9%)	281(72.1%)	390			
	Open well	99(26.3%)	278(73.7%)	377			
	Open spring	739(31.1%)	1634(68.9%)	2373			
	Covered well	102(31.1%)	226(68.9%)	328			
	Covered spring	35(20.7%)	134(79.3%)	169			
	River	102(29.8%)	240(70.2%)	342			
	Pond/lake/dam	135(34.6%)	255(65.4%)	390			
	Other	31(24.6%)	95(75.4%)	126			
Number of living children in the family	1-4	1246(25.1%	3720(74.9%)	4966	67.726	2	<.0001
	5-9	1114(33.4%)	2223(66.6%)	3337			
	10 and above	67(30.2%)	155(69.8%)	222			
Current contraceptive method	Not using	2039(30.2%)	4721(69.8%)	6760	212.788	10	<.0001
	Pill	249(35.1%)	460(64.9%)	709			
	IUD	59(29.4%)	12(70.6%)	17			
	Injections	77(21.3%)	284(78.7%)	361			
	Diaphragm	1(0.2%)	428(99.8%)	429			
	Condom	8(42.1%)	11(57.9%)	19			
	Female Sterilization	1(12.5%)	7(87.5%)	8			
	Male Sterilization	9(16.1%)	47(83.9%)	56			
	Periodic Abstinence	25(22.5%)	86(77.5%)	111			
	Withdrawal	5(35.7%)	9(64.3%)	14			
	Other	8(19.5%)	33(80.5%)	41			
Current marital status of the mother	Never married	126(27.7%)	329(72.3%)	455	1.270	5	.938

	Married	1730(28.5%)	4346(71.5%)	6076			
	Living together	273(29.5%)	653(70.5%)	926			
	Widowed	100(29.3%)	241(70.7%)	341			
	Divorced	131(27.2%)	351(72.8%)	482			
	Not living together	67(27.3%)	178(72.7%)	245			
parental occupation	Not working	808(32.7%)	1660(67.3%)	2468	33.861	9	<.0001
	Prof., Tech., Manag.	51(29.1%)	124(70.9%)	175			
	Clerical	59(27.6%)	155(72.4%)	214			
	Sales	266(27.7%)	695(72.3%)	961			
	Agric-self employed	492(26.4%)	1372(73.6%)	1864			
	Agric-employee	461(26.5%)	1281(73.5%)	1742			
	Household & domestic	109(26.0%)	310(74.0%)	419			
	Services	19(21.6%)	69(78.4%)	88			
	Skilled manual	145(27.6%)	380(72.4%)	525			
	Unskilled manual	17(24.6%)	52(75.4%)	69			
Birth order number of the child	1	359(23.6%)	1163(76.4%)	1522	30.161	3	<.0001
	2-3	723(29.1%)	1759(70.9%)	2482			
	4-5	559(27.6%)	1465(72.4%)	2024			
	6+	786(31.5%)	1711(68.5%)	2497			
sex of the child	Male	1114(26.3%)	3124(73.7%)	4238	19.726	1	<.0001
	Female	1313(30.6%)	2974(69.4%)	4287			
Had fever in last two weeks	No	1334(26.7%)	3666(73.3%)	5000	41.499	2	<.0001
	Yes	1093(31.4%)	2385(68.6%)	3478			
	Don’t know	0(0.0%)	47(100.0%)	47			
Had cough in last two weeks	No	1065(24.0%)	3381(76.0%)	4446	93.460	2	<.0001
	Yes, last two weeks	1361(33.4%)	2713(66.6%)	4074			
	Don’t know	1(20.0%)	4(80.0%)	5			
Age in the child months	<6months	262(40.9%)	379(59.1%)	641	93.460	5	<.0001
	6-11 months	299(33.8%)	586(66.2%)	885			
	12-23 months	623(33.5%)	1235(66.5%)	1858			

	24-35 months	453(26.6%)	1250(73.4%)	1703			
	36-47 months	413(23.0%)	1382(77.0%)	1795			
	48-59 months	377(22.9%)	1266(77.1%)	1643			

Table A2: Distribution of socio-economic, demographic, health and environmental characteristics of stunting status for the 2005 survey

Variables		stunting status of a child				
		not stunted	Stunted			
		Count (%)	Count(%)	Chi-square	df	p-value
Region	Tigray	107(25.4%)	315(74.6%)			
	Afar	96(42.3%)	131(57.7%)			
	Amhara	163(32.0%)	347(68.0%)			
	Oromiya	283(36.6%)	491(63.4%)			
	Somali	117(48.0%)	127(52.0%)			
	Ben-Gumz	96(33.0%)	195(67.0%)	45.420	10	<.0001
	SNNP	249(36.7%)	430(63.3%)			
	Gambela	62()34.3%	119(65.7%)			
	Harari	77(36.0%)	137(64.0%)			
	Addis Abeba	54(40.2%)	91(60.8%)			
	Dire Dawa	65(37%)	104(63%)			
	Total	1369(35.5%)	2487(64.5%)			
Type of place of residence	Urban	492(58.2%)	354(41.8%)			
	Rural	877(29.1%)	2133(70.9%)	242.876	1	<.0001
	Total	1369(35.5%)	2487(64.5%)			
parental educational level	No education	964(35.3%)	1768(64.7%)			
	Primary	169(25.5%)	494(74.5%)			
	Secondary	64(26.6%)	177(73.4%)	212.511	3	<.0001
	Higher	172(78.2%)	48(21.8%)			
	Total	1369(35.5%)	2487(64.5%)			
Source of drinking water	piped in dwelling	3(30.0%)	7(70.0%)			
	piped into compound	81(40.3%)	120(59.7%)			
	piped outside compound	210(33.8%)	412(66.2%)			
	open well water	45(57.7%)	33(42.3%)			
	unprotected well	110(38.2%)	178(61.8%)			
	unprotected spring	77(32.5%)	160(67.5%)			
	tube well/bore hole	2(66.7%)	1(33.3%)			
	protected well	65(30.8%)	146(69.2%)	32.255	12	.0001
	protected spring	392(34.2%)	754(65.8%)			

	River/dam/lake/pond/stream/canal/irrigation channel	374(36.9%)	640(63.1%)			
	Rain water	4(40.0%)	6(60.0%)			
	Tanker truck	3(16.7%)	15(83.3%)			
	Other	3(16.7%)	15(83.3%)			
	Total	1369(35.5%)	2487(64.5%)			
Number of living children in the family	1-4	873(37.1%)	1477(62.9%)			
	5-9	468(34.1%)	903(65.9%)	16.748	2	<.0001
	10 and above	28(20.7%)	107(79.3%)			
	Total	1369(35.5%)	2487(64.5%)			
Current contraceptive method	Not using	1168(35.9%)	2081(64.1%)			
	Pill	37(34.9%)	69(65.1%)			
	IUD	7(63.6%)	4(36.4%)			
	Injections	115(28.5%)	288(71.5%)			
	Condom	4(44.4%)	5(55.6%)			
	Male Sterilization	3(60.0%)	2(40.0%)	27.305	10	<.0001
	male sterilization	7(31.8%)	15(68.2%)			
	Withdrawal	4(33.3%)	8(66.7%)			
	Norplant	2(40.0%)	3(60.0%)			
	lactational amenorrhea	5(71.4%)	2(28.6%)			
	standard day method	17(63.0%)	10(37.0%)			
	Total	1369(35.5%)	2487(64.5%)			
Current marital status	Never married	5(26.3%)	14(73.7%)			
	Married	1279(36.0%)	2272(64.0%)			
	Living together	24(40.0%)	36(60.0%)			
	Widowed	18(22.5%)	62(77.5%)	9.953	5	0.077
	Divorced	29(30.2%)	67(69.8%)			
	Not living together	14(28.0%)	36(72.0%)			
	Total	1369(35.5%)	2487(64.5%)			
parental occupation	Not working	803(38.1%)	1305(61.9%)			
	Prof., Tech., Manag.	13(52.0%)	12(48.0%)			
	Clerical	6(12.0%)	44(88.0%)			
	Sales	123(41.3%)	175(58.7%)			
	Agric-self employed	62(27.6%)	163(72.4%)			
	Agric-employee	150(27.7%)	391(72.3%)	401.155	9	<.0001
	Household & domestic	18(4.9%)	346(95.1%)			
	Services	12(80.0%)	3(20.0%)			
	Skilled manual	31(91.2%)	3(8.8%)			

	Unskilled manual	151(77.0%)	45(23.0%)			
	Total	1369(35.5%)	2487(64.5%)			
Birth order number of a child	1	231(34.3%)	442(65.7%)			
	2-3	407(34.1%)	786(65.9%)	8.745	3	0.033
	4-5	306(33.8%)	598(66.2%)			
	6+	425(39.1%)	661(60.9%)			
	Total	1369(35.5%)	2487(64.5%)			
Sex of child	Male	571(29.3%)	1376(70.7%)			
	Female	798(41.8%)	1111(58.2%)	65.509	1	<0.0001
	Total	1369(35.5%)	2487(64.5%)			
Had fever in last two weeks	No	1106(36.5%)	1923(63.5%)			
	Yes	258(37.0%)	439(63.0%)			
	DK	5(3.8%)	125(96.2%)	58.943	2	<.0001
	Total	1369(35.5%)	2487(64.5%)			
Had cough in last two weeks	No	1153(36.7%)	1988(63.3%)			
	Yes, last two weeks	213(30.0%)	496(70.0%)			
	DK	3(50.0%)	3(50.0%)	11.775	2	0.003
	Total	1369(35.5%)	2487(64.5%)			
child's age in months	<6months	164(50.5%)	161(49.5%)	78.981	5	<.0001
	6-11months	151(38.9%)	237(61.1%)			
	12-23months	299(39.4%)	460(60.6%)			
	24-35months	285(38.2%)	462(61.8%)			
	36-47months	259(31.3%)	568(68.7%)			
	48-59months	211(26.0%)	599(74.0%)			
	Total	1369(35.5%)	2487(64.5%)			

Table A3: Distribution of socio-economic, demographic, health and environmental characteristics of stunting status for the 2011 survey

		stunting status of a child						
		not stunted		Stunted				
		Count	%	count	%	Chi-square	df	p-value
Region	Tigray	233	37.8%	834	69.2%			
	Affar	326	44.3%	548	55.7%			
	Amhara	258	34.4%	798	66.6%			
	Oromiya	409	38.4%	1085	61.6%			
	Somali	244	49.6%	483	50.4%			
	Benishangul-Gumuz	243	34.6%	577	65.4%	89.387	10	<.0001
	SNNP	424	39.3%	932	60.7%			
	Gambela	220	39.5%	479	60.5%			

	Harari	139	38.4%	409	61.6%			
	Addis Ababa	76	44.9%	229	55.1%			
	Dire Dawa	181	42.6%	392	58.4%			
	Total	2753	40.9%	6766	59.1%			
Type of place of residence	Urban	412	35.7%	1257	64.3%			
	Rural	2341	30.8%	5509	69.2%	17.663	1	<.0001
	Total	2753	40.9%	6766	59.1%			
parental educational level	No education	1743	27.6%	4582	72.4%			
	Primary	568	23.5%	1846	76.5%			
	Secondary	290	56.9%	220	43.1%	331.984	3	<.0001
	Higher	152	56.3%	118	43.7%			
	Total	2753	40.9%	6766	59.1%			
Source of drinking water	Piped into dwelling	13	26.5%	36	73.5%			
	Piped to yard/plot	139	25.8%	400	74.2%			
	Public tap/standpipe	432	25.0%	1293	75.0%			
	Tube well/ borehole	149	27.1%	401	72.9%			
	Protected well	230	25.4%	677	74.6%			
	Unprotected well	132	25.2%	392	74.8%			
	surface water	319	79.0%	85	21.0%			
	protected spring	156	24.1%	490	75.9%	565.411	15	<.0001
	unprotected spring	484	25.9%	1383	74.1%			
	river/dam/lake/pond/stream/canal/irrigation channel	530	28.6%	1320	71.4%			
	rain water	26	35.1%	48	64.9%			
	tanker truck	24	40.0%	36	60.0%			
	cart with small tank	27	31.8%	58	68.2%			
	bottled water	30	57.7%	22	42.3%			
	Other	18	47.4%	20	52.6%			
	not dejure resident	44	29.5%	105	70.5%			
	Total	2753	40.9%	6766	59.1%			
Number of living children in the family	1-4	1775	29.3%	4280	70.7%			
	2-3	946	30.6%	2148	69.4%	78.545	2	<.0001
	10 and above	32	8.6%	338	91.4%			
	Total	2753	40.9%	6766	59.1%			
Current contraceptive method	Not using	1937	28.1%	4960	71.9%			
	Pill	41	24.7%	125	75.3%			
	IUD	9	26.5%	25	73.5%			
	Injections	316	22.3%	1103	77.7%			
	Diaphragm	94	40.0%	141	60.0%			

	Condom	5	26.3%	14	73.7%	262.374	10	<.0001
	Female sterilization	2	22.2%	7	77.8%			
	Male sterilization	262	50.5%	257	49.5%			
	Periodic abstinence	16	25.8%	46	74.2%			
	Withdrawal	4	6.2%	60	93.8%			
	Other	67	70.5%	28	29.5%			
	Total	2753	40.9%	6766	59.1%			
Current marital status	not married	309	62.7%	184	37.3%			
	Married	2136	26.9%	5818	73.1%			
	Living with partner	135	28.8%	333	71.2%			
	Widowed	54	32.0%	115	68.0%			
	Divorced	75	26.0%	214	74.0%	291.905	5	<.0001
	No longer living together/separated	44	30.1%	102	69.9%			
	Total	2753	40.9%	6766	59.1%			
parental occupation	Not working	1314	30.5%	2991	69.5%			
	Professional/technical/managerial	26	35.6%	47	64.4%			
	Clerical	19	40.4%	28	59.6%			
	Sales	304	24.8%	920	75.2%			
	Agricultural - self employed	314	36.8%	540	63.2%	64.394	10	<.0001
	Agricultural – employee	444	25.8%	1278	74.2%			
	Household and domestic	139	24.1%	438	75.9%			
	Services	18	22.5%	62	77.5%			
	Skilled manual	157	28.1%	401	71.9%			
	Unskilled manual	7	17.9%	32	82.1%			
	Other	11	27.5%	29	72.5%			
	Total	2753	40.9%	6766	59.1%			
Birth order number of a child	1	465	25.9%	1328	74.1%			
	2-3	837	27.5%	2204	72.5%			
	4-5	656	29.5%	1565	70.5%			
	6+	795	32.3%	1669	67.7%	24.478	3	<0.0001
	Total	2753	28.9%	6766	71.1%			
Sex of child	Male	1584	38.4%	3798	61.6%			
	Female	1169	42.4%	4204	57.6%	17.351	1	<0.0001
	Total	2753	28.9%	2562	68.7%			
Had fever in last two weeks	No	2131	28.1%	5452	71.9%			
	Yes	613	32.2%	1292	67.8%	12.306	2	0.002
	Dk	9	29.0%	22	71.0%			

	Total	2753	40.9%	6766	59.1%			
Had cough in last two weeks	No	1756	25.3%	5187	74.7%			
	Yes, last 24 hours	303	72.0%	118	28.0%			
	Yes, last two weeks	689	32.2%	1448	67.8%	435.524	3	<0.0001
	Dk	5	27.8%	13	72.2%			
	Total	2753	40.9%	6766	59.1%			
Child's age in months	<6months	472	40.4%	696	59.6%			
	6-11months	339	39.8%	513	60.2%			
	11-23months	471	25.4%	1383	74.6%			
	24-35months	979	35.7%	1761	64.3%	406.205	5	<0.0001
	36-47months	453	16.4%	2302	83.6%			
	48-59months	39	26.0%	111	74.0%			
	Total	2753	40.9%	6766	59.1%			

Table A4: Binary Logistic Regression Analysis Result for the 2000 survey year

Predictor variables	Estimate	S.E.	Wald	Df	p-value	Exp(Estimate)	95% C.I.for EXP(Estimate)	
							Lower	Upper
Region			**338.044**	**10**	**.000***			
Tigray(ref)								
Afar	-.227	.175	1.695	1	.193	.797	.566	1.122
Amhara	-.381	.149	6.567	1	.010*	.683	.511	.914
Oromia	-.496	.138	12.974	1	.000*	.609	.465	.798
Somali	-.059	.206	.081	1	.776	.943	.630	1.412
Benishangul	.070	.172	.164	1	.685	1.072	.766	1.501
SNNPR	-.336	.151	4.953	1	.026*	.714	.531	.961
Gambela	.157	.192	.672	1	.412	1.170	.804	1.703
Harari	.521	.212	6.050	1	.014*	1.683	1.112	2.548
Addis Ababa	-.986	.148	44.288	1	.000*	.373	.279	.499
Dire Dawa	-1.466	.141	107.925	1	.000*	.231	.175	.304
Place of residence			**109.942**	**1**	**.000***			
Urban(ref)								
Rural	.715	.068	109.942	1	.000*	2.044	1.788	2.336
Parental education level			**229.237**	**3**	**.000***			
No education(ref)								
Primary	-.047	.074	.401	1	.527	.954	.826	1.103
Secondary	.349	.082	18.235	1	.000*	1.417	1.208	1.663

Higher	-3.497	.248	198.465	1	.000*	.030	.019	.049
Source of drinking water			**102.976**	**11**	**.000***			
Piped water (ref)								
Piped into dwelling	-.283	.354	.642	1	.423	.753	.377	1.507
Piped into compound	.670	.890	.567	1	.451	1.955	.342	11.181
Piped into outside compound	.140	.300	.218	1	.641	1.150	.639	2.070
Water from open well	-.476	.293	2.640	1	.104	.621	.350	1.103
Open well	-.653	.315	4.305	1	.038	.521	.281	.964
Open spring	-.460	.314	2.145	1	.143	.631	.341	1.168
covered well	-.735	.292	6.318	1	.012	.480	.270	.851
Covered spring	-.606	.316	3.673	1	.055	.546	.294	1.014
River	1.015	.357	8.085	1	.004	2.760	1.371	5.557
Pond/lake/dam	-.296	.316	.877	1	.349	.744	.400	1.382
Other	-.944	.311	9.199	1	.002	.389	.211	.716
Number of living children in family			**17.385**	**2**	**.000***			
1-4								
5-9	-.278	.068	16.653	1	.000*	.757	.662	.865
10 and above	.013	.180	.005	1	.944	1.013	.711	1.442
Current contraceptive method			**72.614**	**10**	**.000***			
Not using (ref)	-.186	.105	3.169	1	.075	.830	.676	1.019
Pill	-.106	.607	.030	1	.862	.899	.273	2.959
IUD	.729	.150	23.574	1	.000*	2.073	1.545	2.783
Injection	5.187	1.002	26.778	1	.000*	178.925	25.087	1276.107
Diaphragm	-.163	.553	.087	1	.768	.850	.288	2.511
Male condom	.654	1.099	.354	1	.552	1.923	.223	16.561
Female sterilization	1.277	.414	9.511	1	.002*	3.587	1.593	8.077
Male sterilization	.600	.260	5.317	1	.021*	1.823	1.094	3.036
Periodic Abstinence	-.090	.621	.021	1	.885	.914	.270	3.089
Withdrawal	.834	.431	3.738	1	.053	2.303	.989	5.363
Marital status of mother			**20.651**	**5**	**.001***			
Never married (ref)								
Married	-.368	.138	7.138	1	.008*	.692	.528	.907
Living together	-.519	.163	10.127	1	.001*	.595	.432	.819
Widowed	-.667	.184	13.199	1	.000*	.513	.358	.736

Divorced	-.434	.190	5.254	1	.022*	.648	.447	.939
Not living together	-.767	.211	13.251	1	.000*	.464	.307	.702
Parental occupation			83.636	9	.000*			
Not working (ref)								
Professional/ technical/managerial	.711	.248	8.231	1	.004*	2.037	1.253	3.312
Clerical	.210	.195	1.159	1	.282	1.233	.842	1.806
Sales	.056	.111	.252	1	.616	1.057	.851	1.314
Agricultural self-employee	.682	.089	59.296	1	.000*	1.979	1.663	2.354
Agricultural employee	.327	.088	13.828	1	.000*	1.386	1.167	1.647
Household and domestic	.648	.145	19.885	1	.000*	1.912	1.438	2.543
Services	.602	.290	4.315	1	.038*	1.827	1.035	3.225
Skilled manual	.004	.129	.001	1	.975	1.004	.779	1.294
Unskilled manual	.122	.314	.150	1	.698	1.130	.610	2.092
Birth order of a child			**10.918**	**3**	**.012***			
1(ref)								
2-3	-.229	.083	7.630	1	.006*	.796	.676	.936
4-5	-.187	.089	4.377	1	.036*	.830	.697	.988
6+	-.289	.095	9.253	1	.002*	.749	.621	.902
Sex of a child			**20.072**	**1**	**.000***			
Male (ref)								
Female	-.241	.054	20.072	1	.000*	.786	.708	.873
Had fever in last two weeks			**5.655**	**2**	**.059**			
No (ref)								
Yes, last two weeks	-.155	.065	5.655	1	.017*	.856	.754	.973
Don't know	20.401	5526.400	.000	1	.997	724569823.719	.000	.
Had cough in last two weeks			**52.799**	**2**	**.000***			
No (ref)								
Yes	-.460	.063	52.798	1	.000*	.631	.558	.715
Don't know	-.188	1.135	.027	1	.868	.828	.090	7.667
Age of a child			**50.794**	**5**	**.000***			
<6months(ref)								
6-11months	.243	.119	4.160	1	.041*	1.275	1.010	1.611
12-23months	.004	.106	.001	1	.972	1.004	.816	1.235
24-35months	.200	.111	3.276	1	.070	1.222	.984	1.517

36-47months	.423	.111	14.406	1	.000*	1.526	1.227	1.898
48-59months	.529	.114	21.600	1	.000*	1.696	1.357	2.120
Constant	2.008	.367	29.862	1	.000*	7.449		

Table A5: Binary Logistic Regression Analysis Result for the 2005 survey

Predictor variables	Estimate	S.E.	Wald	Df	p-value	Exp(Estimate)	95% C.I.for EXP(Estimate)	
							Lower	Upper
Region			**25.049**	**10**	**.005***			
Tigray (ref)	-.782	.210	13.830	1	.000*	.457	.303	.691
Afar	-.542	.174	9.767	1	.002*	.581	.414	.817
Amhara	-.569	.162	12.277	1	.000*	.566	.412	.778
Oromia	-.845	.206	16.865	1	.000*	.430	.287	.643
Somali	-.390	.197	3.896	1	.048*	.677	.460	.997
Benishangul	-.580	.167	12.093	1	.001*	.560	.404	.776
Gambela	-.516	.234	4.890	1	.027*	.597	.378	.943
Harari	-.426	.216	3.868	1	.049	.653	.428	.999
Addis Ababa	-.181	.286	.399	1	.527	.835	.477	1.461
Dire Dawa	-.559	.244	5.270	1	.022*	.572	.355	.922
Place of residence			**112.385**	**1**	**.000***			
Urban (ref)								
Rural	1.192	.112	112.385	1	.000*	3.294	2.643	4.107
Parental education level			**171.987**	**3**	**.000***			
No education(ref)								
Primary	.495	.113	19.122	1	.000*	1.641	1.314	2.048
Secondary	.473	.205	5.322	1	.021*	1.604	1.074	2.398
Higher	-2.258	.202	125.340	1	.000*	.105	.070	.155
Source of drinking water			**37.778**	**12**	**.000***			
Piped in dwelling(ref)								
Piped into compound	-1.224	.816	2.252	1	.133	.294	.059	1.455
Piped outside compound	-1.415	.794	3.172	1	.075	.243	.051	1.153
Open well water	-3.700	.929	15.847	1	.000*	.025	.004	.153
Unprotected well	-1.693	.805	4.426	1	.035*	.184	.038	.891
Unprotected spring	-1.421	.809	3.083	1	.079	.242	.049	1.179
Tube well/bore hole	-2.880	1.731	2.768	1	.096	.056	.002	1.670
Protected well	-1.529	.812	3.550	1	.060	.217	.044	1.064
Protected spring	-1.657	.797	4.325	1	.038*	.191	.040	.909
River/dam/pond/lake/stream/canal/irrigation channel	-1.679	.796	4.447	1	.035*	.187	.039	.888

Rain water	-1.137	1.111	1.047	1	.306	.321	.036	2.831
Tanker truck	-.039	1.038	.001	1	.970	.961	.126	7.348
Other	-.711	1.033	.474	1	.491	.491	.065	3.717
Number of living children			**8.647**	**2**	**.013***			
1-4(ref)								
5-9	.088	.087	1.019	1	.313	1.091	.921	1.294
10 and above	.734	.256	8.256	1	.004*	2.084	1.263	3.439
Current contraceptive method			**18.965**	**10**	**.041***			
Not using(ref)								
Pill	.218	.250	.766	1	.381	1.244	.763	2.029
IUD	-.731	.747	.958	1	.328	.481	.111	2.082
Injections	.382	.147	6.698	1	.010*	1.465	1.097	1.956
Condom	.638	.836	.583	1	.445	1.894	.368	9.755
Male sterilization	-1.530	1.054	2.106	1	.147	.217	.027	1.710
Female sterilization	.789	.564	1.957	1	.162	2.201	.729	6.646
Withdrawal	-.368	.735	.251	1	.616	.692	.164	2.921
Norplant	-1.581	1.135	1.940	1	.164	.206	.022	1.903
Lactational amenorrhea	-1.831	1.022	3.214	1	.073	.160	.022	1.186
Standard day method	-.183	.540	.115	1	.734	.833	.289	2.400
Marital status of the mother			**6.190**	**5**	**.288**			
Never married(ref)								
Married	-.613	.637	.926	1	.336	.542	.155	1.888
Living together	-.591	.708	.698	1	.403	.554	.138	2.216
Widowed	-.096	.702	.019	1	.891	.909	.229	3.598
Divorced	-.188	.691	.074	1	.786	.829	.214	3.214
Not living together	-.391	.729	.288	1	.591	.676	.162	2.822
Parental occupation			**190.371**	**9**	**.000***			
Not working(ref)								
Professional/technical/managerial	1.027	.543	3.577	1	.059	2.792	.963	8.092
Clerical	.028	.678	.002	1	.967	1.029	.272	3.886
Sales	.010	.142	.005	1	.942	1.010	.764	1.336
Agric-self employee	.451	.177	6.495	1	.011*	1.569	1.110	2.219
Agric- employee	.337	.121	7.736	1	.005*	1.401	1.105	1.777
Household and domestic	2.391	.257	86.284	1	.000*	10.924	6.596	18.092
Services	-2.384	.693	11.822	1	.001*	.092	.024	.359
Skilled manual	-3.142	.617	25.943	1	.000*	.043	.013	.145
Unskilled manual	-1.256	.194	41.817	1	.000*	.285	.195	.417

Birth order of a child			**9.258**	**3**	**.026**			
1(ref)								
2-3	.048	.119	.166	1	.684	1.050	.831	1.325
4-5	.047	.126	.140	1	.708	1.048	.819	1.341
6+	-.226	.120	3.539	1	.060	.797	.630	1.010
Sex of a child			**7.956**	**1**	**.005***			
Male (ref)								
Female	-.235	.083	7.956	1	.005*	.791	.672	.931
had fever in last two weeks before survey			**35.653**	**2**	**.000***			
No (ref)								
Yes	-.115	.117	.954	1	.329	.892	.708	1.122
Don't know	3.286	.567	33.627	1	.000*	26.737	8.806	81.185
Had cough in last two weeks before survey			**1.654**	**2**	**.437**			
No (ref)								
Yes	.156	.123	1.611	1	.204	1.169	.919	1.486
Don't know	-.169	.978	.030	1	.863	.844	.124	5.743
Age of a child			**75.241**	**5**	**.000***			
<6months(ref)								
6-11months	.501	.174	8.316	1	.004*	1.650	1.174	2.319
12-23months	.546	.154	12.558	1	.000*	1.727	1.277	2.336
24-35months	.627	.155	16.404	1	.000*	1.872	1.382	2.535
36-47months	.908	.155	34.392	1	.000*	2.480	1.831	3.359
48-59months	1.249	.159	61.749	1	.000*	3.485	2.553	4.759
Constant	1.583	1.044	2.299	1	.129	4.868		

Table A6: Binary Logistic Regression Analysis Result for the 2011 survey year

Predictor variables	Estimate	S.E.	Wald	Df	p-value	Exp(Estimate)	95% C.I.for EXP(Estimate)	
							Lower	Upper
Region			**51.207**	**10**	**.000***			
Tigray (ref)								
Affar	-.718	.129	30.935	1	.000*	.488	.379	.628
Amhara	-.208	.120	3.004	1	.083	.812	.642	1.028
Oromia	-.370	.113	10.738	1	.001*	.691	.554	.862
Somali	-.481	.141	11.656	1	.001*	.618	.469	.815
Benishangul	-.534	.127	17.694	1	.000*	.587	.457	.752
SNNPR	-.556	.116	23.033	1	.000*	.573	.457	.720

Gambela	-.274	.135	4.097	1	.043*	.760	.583	.991
Harari	-.220	.147	2.237	1	.135	.803	.602	1.071
Addis Ababa	-.254	.198	1.641	1	.200	.776	.526	1.144
Dire Dawa	-.610	.144	17.986	1	.000*	.543	.410	.720
Place of residence			**38.944**	**1**	**.000***			
Urban(ref)								
Rural	-.615	.099	38.944	1	.000*	.541	.446	.656
Parental education level			**258.295**	**3**	**.000***			
No education (ref)								
Primary	.004	.068	.003	1	.958	1.004	.879	1.146
Secondary	-1.617	.127	160.766	1	.000*	.199	.155	.255
Higher	-1.999	.176	129.654	1	.000*	.135	.096	.191
Source of drinking water			**290.528**	**15**	**.000***			
Piped into dwelling(ref)								
Pipe into yard/plot	.005	.391	.000	1	.989	1.005	.467	2.165
Public tab/stand pipe	.063	.388	.026	1	.872	1.065	.497	2.279
Tube well/bore hole	.140	.405	.119	1	.730	1.150	.520	2.543
Protected well	.046	.398	.013	1	.908	1.047	.480	2.285
Unprotected well	.192	.405	.224	1	.636	1.211	.548	2.679
Surface water	-2.132	.407	27.511	1	.000*	.119	.053	.263
Protected spring	.213	.402	.282	1	.596	1.238	.563	2.721
River/lake/pond/dam/stream/canal/irrigation channel	.115	.393	.085	1	.770	1.122	.519	2.425
Rain water	.030	.394	.006	1	.940	1.030	.476	2.228
Tanker truck	-.330	.480	.474	1	.491	.719	.281	1.840
Cart with small tank	-.558	.495	1.269	1	.260	.572	.217	1.511
Bottled water	-.515	.465	1.229	1	.268	.597	.240	1.486
Dug well	-1.336	.493	7.352	1	.007*	.263	.100	.691
Other	-.561	.553	1.030	1	.310	.571	.193	1.686
Not dejure resident	-.040	.436	.008	1	.928	.961	.409	2.261
Number of living children in the family			**34.976**	**2**	**.000***			
1-4(ref)								
5-9	-.030	.089	.113	1	.737	.971	.816	1.155
10 and above	1.199	.210	32.534	1	.000*	3.317	2.197	5.007
Current contraceptive method			**274.810**	**10**	**.000***			
Not using (ref)								
Pill	2.345	.260	81.021	1	.000*	10.431	6.260	17.380
IUD	.901	.494	3.323	1	.068	2.463	.934	6.490

Injections	-.045	.082	.302	1	.582	.956	.815	1.122
Diaphragm	-.914	.150	37.304	1	.000*	.401	.299	.537
Condom	.003	.576	.000	1	.996	1.003	.325	3.101
Female sterilization	-.047	.845	.003	1	.955	.954	.182	5.000
Male sterilization	-.867	.110	62.141	1	.000*	.420	.339	.521
Periodic abstinence	.011	.335	.001	1	.974	1.011	.525	1.948
Withdrawal	1.671	.552	9.165	1	.002*	5.319	1.803	15.693
Other	-2.398	.246	95.328	1	.000*	.091	.056	.147
Marital status of mothers			**255.724**	**5**	**.000***			
Not married(ref)								
Married	2.682	.171	246.264	1	.000*	14.618	10.457	20.435
Living with partner	2.378	.203	137.030	1	.000*	10.787	7.244	16.064
Widowed	2.126	.247	73.820	1	.000*	8.385	5.162	13.619
Divorced	2.332	.223	109.509	1	.000*	10.300	6.655	15.941
Not living with partner/separated	2.363	.267	78.271	1	.000*	10.628	6.296	17.941
Parental occupation			**29.239**	**10**	**.001***			
Not working(ref)								
Professional/technical /managerial	.843	.313	7.245	1	.007*	2.323	1.258	4.293
Clerical	.326	.351	.864	1	.353	1.385	.697	2.755
Sales	.173	.087	3.947	1	.047*	1.189	1.002	1.410
Agric-self employee	-.119	.093	1.616	1	.204	.888	.739	1.066
Agric-employee	.021	.081	.068	1	.795	1.021	.871	1.197
Household and domestic	.361	.118	9.420	1	.002*	1.435	1.139	1.806
Services	.638	.314	4.140	1	.042*	1.893	1.024	3.502
Skilled manual	-.004	.119	.001	1	.974	.996	.788	1.259
Unskilled manual	.479	.519	.852	1	.356	1.615	.584	4.469
Other	.815	.447	3.325	1	.068	2.260	.941	5.430
Birth order of a child			**36.241**	**3**	**.000***			
1(ref)								
2-3	-.192	.081	5.651	1	.017*	.825	.705	.967
4-5	-.459	.094	23.781	1	.000*	.632	.525	.760
6+	-.671	.115	33.856	1	.000*	.511	.408	.641
Sex of a child			**42.151**	**1**	**000***			
Male (ref)								
Female	-.356	.055	42.151	1	.000*	.700	.629	.780
Had fever in last two weeks before survey			30.260	2	.000*			
No (ref)								

Yes	.295	.083	12.567	1	.000*	1.343	1.141	1.582
Don't know	2.882	.639	20.337	1	.000*	17.842	5.100	62.421
Had cough in last two weeks before survey			**355.346**	**3**	**.000***			
No (ref)								
Yes, last 24 hours	-2.314	.123	351.031	1	.000*	.099	.078	.126
Yes, last two weeks	-.246	.074	11.146	1	.001*	.782	.676	.903
Don't know	-1.057	.826	1.637	1	.201	.347	.069	1.754
Age of a child			**245.607**	**5**	**.000***			
<6months(ref)								
6-11months	-.236	.109	4.660	1	.031*	.790	.637	.978
12-23months	.393	.096	16.640	1	.000*	1.482	1.227	1.790
24-35months	-.065	.088	.536	1	.464	.937	.788	1.114
36-47months	.929	.095	95.799	1	.000*	2.532	2.102	3.050
48-59months	.734	.221	11.087	1	.001*	2.084	1.353	3.211
Constant	-.147	.438	.113	1	.737	.863		

Table A7: Summary Statistics of the Likelihood ratio Test for the 2000 Survey

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	Df	Sig.
Null model	9738.317			
Final model	9137.295	601.022	13	.000

Table A8: Summary Statistics of the Likelihood ratio Test for the 2005 Survey

Model	Model Fitting Criteria		Likelihood Ratio Tests	
	-2 Log Likelihood	Chi-Square	df	Sig.
Null model	4916.048			
Final model	3820.224	1095.824	65	.000

Table A9: Summary Statistics of the Likelihood ratio Test for the 2011 survey

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Null model	11111.652			
Final model	8770.409	2341.243	71	.000

Table A10: Hosmer-Lemeshow Test for the 2000 survey

Step	Chi-square	df	Sig.
1	10.344	8	.242

Table A11: Hosmer and Lemeshow Test for the 2005 Survey

Step	Chi-square	df	Sig.
1	5.084	8	.749

Table A12: Hosmer and Lemeshow Test for 2011 Survey Year

Step	Chi-square	df	Sig.
1	8.717	8	.367

APPENDIX B

Table B1: Results of Model Diagnostics for 2016 year of survey

	N	Minimum	Maximum
Analog of Cook's influence statistics	8703	.00000	.65116
Leverage value	8703	.00011	.36587
DFBETA for constant	8703	-.04940	.10380
DFBETA for region(1)	8703	-.01152	.01065
DFBETA for region(2)	8703	-.01154	.01158
DFBETA for region(3)	8703	-.01130	.01066
DFBETA for region(4)	8703	-.01223	.01047
DFBETA for region(5)	8703	-.01192	.01177
DFBETA for region(6)	8703	-.01189	.01056
DFBETA for region(7)	8703	-.01238	.01423
DFBETA for region(8)	8703	-.01398	.01063
DFBETA for region(9)	8703	-.01896	.01863
DFBETA for region(10)	8703	-.02080	.01764
DFBETA for placeofres(1)	8703	-.00533	.00561
DFBETA for educlevel(1)	8703	-.00286	.00436
DFBETA for educlevel(2)	8703	-.00866	.01093
DFBETA for educlevel(3)	8703	-.01363	.01982
DFBETA for sofdwater(1)	8703	-.09715	.05765
DFBETA for sofdwater(2)	8703	-.09978	.05358
DFBETA for sofdwater(3)	8703	-.10182	.05201
DFBETA for sofdwater(4)	8703	-.10792	.05065
DFBETA for sofdwater(5)	8703	-.17033	.09172
DFBETA for sofdwater(6)	8703	-.13018	.09157
DFBETA for sofdwater(7)	8703	-.10060	.05194
DFBETA for sofdwater(8)	8703	-.10106	.05161
DFBETA for sofdwater(9)	8703	-.10146	.05161
DFBETA for sofdwater(10)	8703	-.10026	.05185
DFBETA for sofdwater(11)	8703	-.11635	.04970
DFBETA for sofdwater(12)	8703	-.12381	.04977
DFBETA for sofdwater(13)	8703	-.10212	.05234
DFBETA for sofdwater(14)	8703	-.10137	.05237
DFBETA for sofdwater(15)	8703	-.10217	.06674
DFBETA for sofdwater(16)	8703	-.10453	.05138
DFBETA for sofdwater(17)	8703	-.10540	.05213
DFBETA for sofdwater(18)	8703	-.10367	.05093

DFBETA for nofchil(1)	8703	-.00479	.00548
DFBETA for nofchil(2)	8703	-.02567	.02310
DFBETA for contrmethod(1)	8703	-.01805	.02661
DFBETA for contrmethod(2)	8703	-.02983	.03676
DFBETA for contrmethod(3)	8703	-.00531	.00495
DFBETA for contrmethod(4)	8703	-.02100	.03995
DFBETA for contrmethod(5)	8703	-.03939	.03962
DFBETA for contrmethod(6)	8703	-.07561	.03393
DFBETA for contrmethod(7)	8703	-.02136	.01902
DFBETA for contrmethod(8)	8703	-.08256	.26379
DFBETA for contrmethod(9)	8703	-1.20669	.40715
DFBETA for contrmethod(10)	8703	-.01533	.00900
DFBETA for contrmethod(11)	8703	-.01166	.01076
DFBETA for contrmethod(12)	8703	-.10286	.32006
DFBETA for contrmethod(13)	8703	-.04548	.35291
DFBETA for marstatus(1)	8703	-.02357	.01522
DFBETA for marstatus(2)	8703	-.18257	.23843
DFBETA for marstatus(3)	8703	-.03434	.04938
DFBETA for marstatus(4)	8703	-.02458	.02544
DFBETA for marstatus(5)	8703	-.69642	.59757
DFBETA for occup(1)	8703	-.01949	.01768
DFBETA for occup(2)	8703	-.01319	.01388
DFBETA for occup(3)	8703	-.00706	.00764
DFBETA for occup(4)	8703	-.02699	.02674
DFBETA for occup(5)	8703	-.01175	.01126
DFBETA for occup(6)	8703	-.02476	.02676
DFBETA for occup(7)	8703	-.06567	.06694
DFBETA for occup(8)	8703	-.02377	.02482
DFBETA for occup(9)	8703	-.01483	.02452
DFBETA for occup(10)	8703	-.10160	.13096
DFBETA for bord(1)	8703	-.00845	.01117
DFBETA for bord(2)	8703	-.01503	.01518
DFBETA for bord(3)	8703	-.03639	.01177
DFBETA for sex(1)	8703	-.00176	.00200
DFBETA for fever(1)	8703	-.00552	.00611
DFBETA for fever(2)	8703	-.01875	.02109
DFBETA for cough(1)	8703	-.60489	.69295
DFBETA for cough(2)	8703	-.00460	.00487
DFBETA for cough(3)	8703	-.01990	.02240
DFBETA for age(1)	8703	-.00944	.01237

DFBETA for age(2)	8703	-.01321	.01797
DFBETA for age(3)	8703	-.01406	.02582
DFBETA for age(4)	8703	-.01049	.04434
DFBETA for age(5)	8703	-.00946	.00866
Valid N (listwise)	8703		

Table B2: Random intercept only model fit results for the 2000 Survey

stuntstatus	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
_cons	1.10674	.1396825	7.92	0.000	.8329676	1.380513
Random-effects Parameters		Estimate	Std. Err.		[95% Conf. Interval]	
region: Identity var(_cons)		.2042498	.0913184		.0850347	.4905993

LR test vs. logistic regression: chibar2(01) = 309.97 Prob>=chibar2 = 0.0000

Model	Obs	LL vaue	df	AIC	BIC
M0	8525	-4937.256	2	9878.513	9892.614

Table B3: Random intercept only model fit results for the 2005 Survey

stuntstatus	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
_cons	.5768958	.0742378	7.77	0.000	.4313924	.7223991
Random-effects Parameters		Estimate	Std. Err.		[95% Conf. Interval]	
region: Identity var(_cons)		.0448347	.0254273		.0147526	.1362573

LR test vs. logistic regression: chibar2(01) = 19.30 Prob>=chibar2 = 0.0000

Model	Obs	LL Value	df	AIC	BIC
M0	3856	-2498.699	2	5001.399	5013.913

Table B4: Random intercept only model fit results for the 2011 Survey

stuntstatus	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
_cons	.9031604	.0654773	13.79	0.000	.7748272	1.031494
Random-effects Parameters		Estimate	Std. Err.		[95% Conf. Interval]	
region: Identity var(_cons)		.040501	.0199073		.0154553	.1061338

LR test vs. logistic regression: chibar2(01) = 55.14 Prob>=chibar2 = 0.0000

Model	Obs	LL value	df	AIC	BIC
M0	9519	-5697.574	2	11399.15	11413.47