

ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF STATISTICS

WOMEN MALNUTRITION IN ETHIOPIA

BY

WOINSHET GEZAHEGN

A Thesis submitted to the Office of Graduate Programs of Addis Ababa University in Partial fulfillment of the requirements for the Degree of Master Science in Statistics

Addis Ababa University

Addis Ababa, Ethiopia

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School of Graduate Studies

This is to certify that the thesis prepared by Woinshet Gezahegn, entitled: **WOMEN MALNUTRITION 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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ABSTRACT

Women malnutrition in Ethiopia

Woinshet Gezahegn

Addis Ababa University, 2014

Ethiopia, a country with an area of 1.14 million km^2 is located in the region that is known as the Horn of Africa. Malnutrition is a serious problem in Ethiopia, and women and children are the most affected segments of the population. Women are more likely to suffer from malnutrition than men are, for some potential reasons. Given this background the major objective of this study is to identify factors affecting women malnutrition in Ethiopia. In this study the data source was the Ethiopian Demographic and Health Survey conducted in 2011(EDHS 2011) by the Central Statistical Agency (CSA) with a total of 16,515 women of age 15-49 years. In this study 8,278 non-pregnant and non-postpartum women are considered. Descriptive statistics, binary logistic regression and multilevel logistic regression are used for statistical analysis. The descriptive result revealed that about 28.7% of the women were malnourished while 71.3% were not malnourished. Logistic regression analysis was performed to investigate the effect of predicators on women malnutrition. Accordingly, place of residence, region, education level, economic status, source of drinking water, toilet facilities, occupation of women and partner's occupation were found to be the significant determinants for women malnutrition. Moreover, multilevel modeling was used to analyze nested sources of variability in hierarchical data, taking in to account the variability associated within each level of the hierarchy. The estimates of the multilevel model showed that variables that are reported to be significant in logistic regression analysis were also found to be significant. The effect of these significant variables is the same all region in Ethiopia but the effect of economic status and education levels are not the same all regions in Ethiopia.

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Table of Contents

ABSTRACT i
Acknowledgement ii
List of Abbreviations v
List of Tables vi
1. INTRODUCTION 1
1.1. Background of the Study 1
1.2. Statement of the Problem 3
1.3. Objectives of the Study 4
1.3.1. General Objective 4
1.3.2. Specific Objectives 4
1.4. Significance of the Study 5
1.5. Limitations of Study 5
2. LITERATURE REVIEW 6
2.1. Conceptual Framework and Definition of Malnutrition 6
2.2. Women Malnutrition 7
2.3. Causes of Women Malnutrition 9
2.4. Problems Caused by Women Malnutrition 13
2.5. Nutritional Assessment in Women 15
2.6. Prevalence of women malnutrition 16
3. DATA AND METHODOLOGY 17
3.1. Data Source 17
3.2. Study Variables 17
3.2.1. The Dependent Variable 18
3.2.2. Independent Variables 18
3.3. Methodology 21
3.3.1. Logistic Regression Analysis 21
3.3.1.1. Model 21
3.3.1.2. Parameter Estimation 23
3.3.1.3. Statistical Tests of Individual Predictors 24
3.3.1.4. Overall Model Evaluation 24

3.3.1.5. Hosmer-Lemeshow Goodness-of-Fit test 25
3.3.1.6. Model Diagnostics 26
3.3.2. Multilevel Logistic Regression Model 27
3.3.2.1. Two Level Model 27
3.3.2.2. Heterogonous Proportion 28
3.3.2.3. The Empty Two-Level Model 30
3.3.2.4. The Random Intercept Logistic Regression Model 30
3.3.2.5. The Random Coefficient Model 31
3.3.2.6. Intra-class Correlation Coefficient (ICC) 32
3.3.2.7. Parameter Estimation 32
3.3.2.8. Significance Testing in Multilevel Regression 33
3.3.2.8.1. Significance Testing for Fixed Effects 33
3.3.2.8.2. Significance Testing for Random Effects 33
3.3.2.9. Goodness of Fit Test 34
3.3.2.10. Model Diagnostics 34
4. STATISTICAL DATA ANLAYSIS 35
4.1. Results of Descriptive Analysis 35
4.2. Results of Logistic Regression Analysis 38
4.2.1. Model Diagnostics 43
4.3.Results of Multilevel Logistic Regression Analysis 43
4.3.1. Random Intercept Only Model 44
4.3.2. Random Intercept and Fixed Effect Model 45
4.3.3. The Random Coefficient Model 47
4.3.4. Goodness of Fit Test 51
4.3.5. Diagnostic Checking 51
5. DISCUSSION, CONCLUSTION AND RECOMMENDATIONS 52
5.1. Discussion 52
5.2. Conclusion and Recommendations 54
6. REFERENCES 55
7. APPENDIXES 62

List of Abbreviations

- AIC-Akaike Information Criteria
- BIC-Bayesian Information Criteria
- BMI- Body Mass Index
- CED- Chronically Energy Deficient
- CI- Confidence Interval
- CSA-Central Statistical Agency
- DHS- Demographic and Health Survey
- GLIMMIX- Generalized Linear Mixed Model
- IDP- Internally Displaced People
- IDW- Internally Displaced Women
- LR- Likelihood Ratio
- ML- Maximum Likelihood
- MQL- Marginal Quasi Likelihood
- MUAC-Mid-Upper Arm Circumstance
- OLS- Ordinary Least Square
- PQL- Penalized Quasi Likelihood
- S.E- Standard Error
- SNNP- South Nations, Nationality and People
- UK- United Kingdom
- UNICEF-United Nations International Children Fund
- US- United State
- WHO- World Health Organization

List of Tables

- Table 4.1: Results of Descriptive Analysis
- Table 4.2: Results of Maximum Likelihood Estimates of Parameter
- Table 4.3: Result of Model Fit Statistics for Empty and Full Model
- Table 4.4: Test of Significance of Hosmer-Lemeshow Goodness of Fit Statistics
- Table 4.5: Result of Parameter Estimate of Random Intercept Only Model
- Table 4.6: Result of Parameter Estimate of Random Intercept and Fixed Slope Model
- Table 4.7: Model Selection Criteria and Likelihood Ratio Test
- Table 4.8: Result of Parameter Estimate of Random Coefficient Model
- Table 4.9: Random Effect Correlation Matrix for Level Region
- Table 4.10: Results of Model Selection Criteria and Log Likelihood Ratio Test

1. INTRODUCTION

1.1. Background of the Study

Ethiopia, a country with an area of 1.14 million km^2 is located in the region that is known as the Horn of Africa. Malnutrition is a serious problem in Ethiopia, and women and children are the most affected segments of the population. One of every four (26%) women of reproductive age in Ethiopia is malnourished (Central Statistical Authority [Ethiopia] and ORC Macro, 2006), twice the sub-Saharan average of 13.3% (Mukuria et al., 2005). In particular, malnutrition among women is likely to have a major impact on their health as well as their children's health. More than 3.5 million women and children under age five in developing countries die each year due to the underlying cause of under nutrition (Robert et al., 2013).

Going beyond the critical role that nutrition plays in economic and human development, good nutrition is a cornerstone that affects the health of all people, enabling us to reach our fullest potential as individuals and societies. Accordingly, nutrition has long been recognized as a fundamental human right, enshrined in key international conventions. Freedom from hunger and malnutrition was declared a basic human right in the 1948 Universal Declaration of Human Rights. The convention ensures that "Everyone has the right to a standard of living adequate for the health and well-being of himself and his family…" (Article 25).

Under-nutrition, defined as failure to consume adequate energy, protein, and micronutrients to meet basic requirements for body maintenance, growth, and development. Malnutrition and its associated disease conditions can be caused by eating too little, eating too much, or eating an unbalanced diet that lacks necessary nutrients. It is one of the most devastating problems worldwide and is inextricably linked with poverty. Eliminating malnutrition is one of the most fundamental challenges facing humanity. The problems arise from cultural, political and economic realities that must be addressed in tandem.

If Ethiopia seeks sustainable human and economic development, failing to pay attention to child and maternal nutrition issues is shortsighted. This is the case with respect to the human development targets of the Millennium Development Goals, the poverty reduction targets of the Sustainable Development and Poverty Reduction Program, and to any objective of accelerated income growth. In poorly nourished populations, reductions in hunger and improved nutrition convey considerable productivity gains. Such productivity gains are necessary for economic growth. In addition, improved nutrition reduces the need for health services and thus can free up resources for other pressing investments. It is the existence of these sizeable gains, together with cost effective interventions, that underlie the economic case for improving women nutrition in Ethiopia.

Women, throughout most of the world, have the major responsibility for their families' nutrition. Their own nutrition is often impaired, under the social and biological stresses they face. Developments that improve women's position in society are likely to improve nutrition overall, and are essential for this. Equally, any activities aimed at preventing malnutrition depend substantially on women's activities, indeed on their empowerment. At the same time, more attention must be paid to improving women's own nutritional status perhaps an under recognized problem and many of the necessary technologies are now well known. Finally, it is becoming increasingly clear that protecting women's nutrition, notably during pregnancy and lactation but in fact throughout the life cycle, is necessary to safeguard the nutrition of infants, children and indeed future generations.

Programs intended to improve nutritional conditions for women and their families can be more successfully designed and implemented if there is a greater understanding and awareness of the specific roles that women play. This is because women's status and their health (and nutrition) are intricately entwined (Lyons, 1985) so that for any meaningful improvement one must first deal with those ways in which health and nutrition of a woman are affected adversely by the existing social, cultural and economic systems. "A sound nutrition program needs to go beyond the provision of health and nutrition services and to recognize that nutritional problems often have their origins in social and economic systems, and these problems can be solved only by bringing about changes in these systems, particularly at household level" (Rogers and Youssef, 1988).

Many women in poor societies are overworked by too many calls on their time and have too few resources to adequately cope with their circumstances. Women's fatigue is now recognized as a social disease hidden behind the barriers of traditional norms affecting not only their own health and wellbeing, but also their ability to care for the nutrition of their families (Ahooja−Patel, 1980). Nutritional objectives may often best be achieved through measures that enable such women to more effectively cope and better fulfill the roles that they identify for themselves provided that the necessary resources are also available.

The assessment of women nutritional status is accomplished by clinical methods, anthropometric measurements (including body mass index and Mid Upper ArmCircumference.etc), biochemical analysis (including hemoglobin and stool examination, presence of microbes and worms, certain minerals and vitamins), and dietary evaluation methods. Ideally, a combination of methods should be used when assessing nutritional status using standardized techniques. For meaningful interpretation of nutritional assessment, indicators of socio-economic conditions, cultural practices, health statistics, food-related behavior, and knowledge, attitudes and practices should be considered additionally.

Many developing countries have begun to bear the 'dual burden of malnutrition', whereby a growing proportion of the population are suffering from obesity and obesity-related disorders in addition to the large proportion who remain undernourished (SCN 2004). However, this study, therefore, aims at identifying the underlying factors affecting malnutrition (under-nutrition) of women of reproductive age in Ethiopia.

1.2. Statement of the Problem

The nutritional and health status of women is a great concern in the contemporary world, because the multiple roles played by women and low socioeconomic status give rise to serious health and nutritional problems. The situation is even worse in countries where social norms and sex discrimination have forcefully subjected like Ethiopia. Women are, thus, vulnerable to malnutrition for social and biological reasons (Ene-Obong HN *et al.*, 2001).

In 2003, only 1% of adult women were stunted (height <1.45m), but more than one out of ten (12%) had a body mass index <18.5kg/m², defining chronic energy deficiency (CED). Between

1998 and 2003, no drop in malnutrition among women was observed (NCPD, CBS & Macro Int, 1999; CBS, MOH and ORC Macro, 2004). In comparison with data from 1993, the nutritional status of women worsened slightly, with prevalence increasing from 9% to 12% according to the survey (CBS, MOH & ORC Macro, 2004).

As for women in the country, over a quarter had a low body mass index (BMI) (<18.5) in 2005; nearly one third among women 15-19 years of age. (Getahun 2001, Bhutta 2008). In 2005, women's mean height was 157 cm and only 3% measured less than 145 cm, a cut-off below which risks of difficult delivery and of giving birth to a low birth weight baby is higher due to intrauterine growth retardation. Mean body mass index (BMI) was 20 kg/m² and 27% of women of childbearing age were affected by chronic energy deficiency (CED) (BMI<18.5 kg/m²) while only 4% were overweight or obese (BMI≥25.0 kg/m²) (CSA and ORC Macro, 2006).

The oppression of women socially and culturally means they have less access to everything, including food, resources, health care, community support and information. The problems arise from cultural, political and economic realities that must be addressed in tandem. This study want to address how much the problem is series in Ethiopia and its problem not only affect themselves it also affect their families due to the responsibility of women for the families health status. However, this study attempts to identify the major socio-economic, demographic and environmental determinants of women malnutrition in Ethiopia.

1.3. Objectives of the Study

1.3.1. General Objective

The general objective of this study is to identify factors associated with women malnutrition in Ethiopia.

1.3.2. Specific Objective

1. To describe the relationship between factors and women malnutrition in Ethiopia.
2. To identify the variation of women malnutrition within and between regions.

1.4. Significance of the Study

This study set out to investigate the causes of women malnutrition that accelerate maternal mortality, morbidity, poor development and performance of women in Ethiopia, as well as providing information to policy makers and stakeholders that would be useful for policy implications from a global health perspective as well as a country-specific viewpoint. From a global health perspective it will help to evaluate the progress made by countries towards achieving the Millennium Development Goals. Country level, governments would be better informed about where to allocate their scarce resources in their effort to improve the nutritional and health status of women.

1.5. Limitations of Study

- Many factors affect malnutrition as indicated by different studies in different countries (social, economic, political, demographic, biological, etc). This study was undertaken to explore a few of the socio-economic, demographic, and environmental determinants in Ethiopia.
- Some variables are not included in the analysis of this study because of missing values and non-responses (number of child ever born, sanitation facilities... etc).

2. LITERATURE REVIEW

2.1. Conceptual Framework and Definition of Malnutrition

Conceptual framework is defined generally as a structure for supporting or enclosing something else, also it is a set of assumptions, concepts, values, and practices that constitute a way of viewing reality (Collins English Dictionary, 2003).UNICEF defined the nutrition conceptual frame work as a set of assumptions designed to facilitate the process of assessing, analyzing and deciding on what actions to take at all levels of society to resolve nutrition problems. This is also known as the "Triple A" process (Assessment, Analysis, Action) (Shrimpton and Kachondham, 2003).

The global conceptual framework of the causes of malnutrition presents a useful generalized understanding of how malnutrition and/or maternal death are the outcomes of a multisectoral development problem that can be most effectively analyzed in terms of immediate, underlying and basic causes. This framework has become one of the most familiar images within the international nutrition community over the past decade and has helped foster improved understandings and dialogue about the nature and causes of malnutrition. In the model, malnutrition is viewed as one important manifestation of a larger development problem that reaches across multiple sectors and social, political, economic factors.

In the conceptual framework, the degree to which the three underlying determinants (political, economic, and ideological)are expressed, positively or negatively, is a question of available resources. These include the availability of food, the physical and economic access which an individual or household has to that food, the caregiver's knowledge of how to utilize available food and to properly care for the individual, the caregiver's own health status, and the control the caregiver has over resources within the household that might be used to nourish the individual. Additionally, the level of access to information and services for maintaining health, whether curative services are available, and the presence or absence of a healthy environment with clean water, adequate sanitation, and proper shelter all contribute to determining the nutritional status of an individual (Benson, 2005).

2.2. Women Malnutrition

Women are more likely to suffer from malnutrition than men are, for some potential reasons, which involve women's reproductive biology, low social status, poverty and lack of knowledge. Moreover, socio-cultural tradition and disparities of household work pattern can also make the women more susceptible to malnutrition. Additionally menstruation, pregnancy and lactation can lead to nutritional deficiency, which is the most widespread and disabling health related problem among women. According to Lipton and Ravallion women work longer hours to attain the same level of welfare as men do, and that poverty is more likely to be chronic in women, thus they are more prone to poor health and malnutrition (Haseen, 2003).

Globally, 50 percent of all pregnant women are anemic, and at least 120 million women in less developed countries are under weight. Research shows that being underweight hinders women's productivity and can lead to increased rates of illness and mortality. In some regions, the majority of women are underweight: In South Asia, for example, an estimated 60 percent of women are underweight. Many women who are underweight are also stunted, or below the median height for their age. Stunting is a known risk factor for obstetric complications such as obstructed labor and the need for skilled intervention during delivery, leading to injury or death for mothers and their newborns. It also associated with reduced work capacity (Ransom and Elder, 2003).

Anemia affects about 43 percent of women of reproductive age in less developed countries. Women are especially susceptible to iron deficiency and anemia during pregnancy, and about half of all pregnant women in less developed countries are anemic, although rates vary significantly among regions. Iron deficiency and anemia cause fatigue, reduce work capacity, and make people more susceptible to infection. Severe anemia places women at higher risk of death during delivery and the period following childbirth. Research suggests that even mild anemia puts women at greater risk of death (Ransom and Elder, 2003).

At the local and household level, the impact of the loss of women cannot be underestimated. From a social and economic point of view, the loss of women is more dramatic than that of child (though both are equally regrettable). Women of reproductive age are at greater risk of under nutrition than other groups in Southern Sudan because energy and nutrient needs are high due to

heavy workloads and frequent pregnancies, Iron needs increase during pregnancy, and blood is lost during menstruation and childbirth so Anemia is common, Traditional food sharing behaviors in some households may result in women's diets being less adequate than those of men (Burgess and Danga, 2008).

An estimated 450 million adult women in developing countries are stunted as a result of childhood malnutrition. In Bangladesh women were found to be short and underweight. The mean height and weight was 148cm and 40kg respectively. About one third of women were found chronically malnourished (height <145cm). According to BMI (<18.5 kg/m2) more than half of women were chronic energy deficient among these energy deficient women, 14% were severely energy deficient (<16.0 kg/m2). Anemia was found in about half of the women of study population. Micronutrient deficiency especially deficiencies in iron, iodine and vitamin A are even more widespread worldwide than that of protein energy malnutrition (PEM). Besides being important causes of disability, micronutrient deficiencies often underlie other types of morbidity. Worldwide about 40 percent of non-pregnant and 50 percent of all pregnant women are anemic. Around250 million women suffer the effects of iodine deficiency worldwide. About 6% women are blind due to vitamin A deficiency globally and 13% in Bangladesh (Haseen, 2003).

The Nigeria food consumption and nutrition survey (2001-2003) showed that 11.6 percent of women of child bearing age were chronically energy deficient (CED) or underweight or thin (Body Mass Index <18.5). The proportion of underweight women was as high as16.4 percent in the dry savannah, 10 percent in the moist savannah and 9 percent in the humid forest zone (Ajieroh, 2009). Some evidence in developing countries indicates that malnourished women, with a BMI below 18.5, show a progressive increase in mortality rates as well as increased risk of illness (Genebo and Girma, 2002). Mean BMI scores showed very small progress between the two surveys conducted in Ethiopia, from 19.8 in 2000 to 20.3 in 2005. In line with this the level of under nutrition (BMI<18.5) showed a decline from 30.5% to 26.9%. Women residing in rural areas constituted the majority of the proportion undernourished (85% in 2000 and 86% in 2005). Considering the degrees of under nutrition, most of the women were in the mildly thin category, BMI=17-18.4 (19.4% in 2000, 18.0% in 2005), followed by moderately thin (6.8%, 5.4%) and severely thin (4.3%, 3.5%), among all chronically under-nourished women (Bitew and Telake, 2010).

Studies in India, Bangladesh and Pakistan have shown chronic energy deficiency in nearly 70 percent of women. In Africa, between 20-40 percent of women are malnourished. Rates of malnutrition in India, and also other South Asian countries are higher than those of many poorer countries including those in Sub-Saharan Africa; this phenomenon has been called the '*Asian Enigma*'. One of the main factors to which this is attributed is the poor status of women (Ramalingaswamy et al., 1996). Studies have also looked at economic factors, child care practices, health seeking behavior etc. for explaining malnutrition. In Indian study 20.2% males and 25.2% females were malnourished in the Sangrur district of Punjab, India. Value for BMI >30 kg/m2 is 8.31% in females and 5.04% in males. Most of the women were illiterate and housewives (Dewan, 2008). While malnutrition in India is prevalent among all segments of the population but poor nutrition among women begins in infancy and continues throughout their lifetimes. Women and girls are typically the last to eat in a family; thus, if there is not enough food they are the ones to suffer most. (Horowitz and Kishwar, 1985; Chatterjee, 1990; Desai, 1994 and Zulfiqaret.al., 2004).

2.3. Causes of Women Malnutrition

Malnutrition remains the nutrition problem of greatest concern which is an important determinant of health and an important outcome of ill health. Women become malnourished because of illness combined with inadequate dietary intake. As a consequence of their lower status overall, women experience discrimination in the allocation of household resources including food and access to health services. Various studies on nutrition have been undertaken and conclusions were reached by different scholars in the past regarding nutritional status of women. The detailed literature review presented below focuses on the socioeconomic, demographic, and environmental determinants of malnutrition in women.

Malnutrition varies from country to country depending on economic, ecological, social, and other factors. In Ethiopia at present the most serious nutritional problems are mainly due to low intake of foods in general. Any change in income or income from influence of the nutritional status at the household and individual levels. The effect of income is measured by expenditure on food which reflects a household's income and resources. Study conducted by Bayesian Approach to identify predictors of nutritional status in Ethiopia, the main predictors of nutritional status

were place of residence, education levels, occupation, source of water drinking, age and etc (Mengistu K, Alemu K, Destaw B, 2013).

The economic status of a household is an indicator of access to adequate food supplies, use of health services, availability of improved water sources, and sanitation facilities which are prime determinants of individual nutritional status (UNICEF, 1990; Genebo and Girma, 2002). More resources available to a household should translate into higher expenditures on food and health and result in improved nutrition (Charmarbagwala et al., 2005). In poor households, women are highly vulnerable to nutritional insufficiencies because of their increased need for food and nutrients during pregnancy and lactation. It is frequently asserted that 70 percent of the world's poor are women (UNDP, 1995, United Nations, 1996). This distribution implies that globally there are 900 million poor females and 400 million poor males (Marcoux, 1998). This "excess" of 500 million poor females accelerated malnutrition of women. Malnutrition is especially critical for women because inadequate nutrition causes not only her own health but also that of their children. Women with children in poor society deprive themselves of food to feed their children. As a consequence, 20-45% women of childbearing age in developing countries do not eat WHO recommended 2250 Kcal/day. Earlier studies in Bangladesh conclude that men receive more calories than women, and girls receive proportionately fewer calories than others in the household.

Education is one of the most important resources that enable women to provide appropriate care for themselves and their children, which is an important determinant of children's growth and development (Engle et al., 1997). There is considerable evidence across countries that the nutritional status of women varies directly with the level of their education (Benson, 2004). Women education, as part of parental education, influences child nutrition outcomes through the effect of higher incomes and better use of available information about child health and nutrition (Garrett and Ruel, 1999; Smith et al., 2005; Charmarwabagwala et al., 2005). It is common knowledge that women who receive even minimal education are generally more aware than those who have no education of how to utilize available resources for the improvement of their own nutritional status and that of their families (Behrman and Rosenzweig, 2002; Plug, 2004; Benson, 2004; Grossman, 2006).

Using household data from three consecutive welfare monitoring surveys of Ethiopia over the period 1996-1998, Christiaensen and Alderman (2001) using linear regression analysis found that both female and male adult (parental) education has a strong positive and statistically significant effect on the nutritional status of individual, and the effect of female education is about twice as large as that of male education. This study also shows that maternal nutritional knowledge is key determinants of chronic malnutrition in Ethiopia. Other studies also report similar results from female's education (Woldemariam and Timotiows, 2002; Alemu et al., 2005b; Silva, 2005).

The Caregiver's UK survey highlighted the fact that caregiver's (women) are not getting the vital advice or information they need. 60% of those who responded were worried about the nutrition of the person they care for. These worries are often unaddressed because of insufficient knowledge of a caregiver's (women) how to care them and don't know where to find help and receive information and, at times, encounter a lack of willingness from healthcare professionals to intervene and provide support (Malnutrition Task Force, 2013).

Marital status of women is associated with their social and economic status that affects their nutritional status. This condition may also affect the level of resources available for the care of the child. Nutritional and social security's could be endangered by a negative change in marital status. A study on the SNNPR Region of Ethiopia showed that women's malnutrition is significantly associated with marital status. Malnutrition is higher among unmarried rural and divorced/separated urban women compared to married ones (Teller and Yimar, 2000).

Sector experts assess that some 50% of the consequences of under nutrition maybe caused environmental factors, including a lack of access to safe water and sanitation and/or poor hygiene practices that leads to exposure to repeated enteric infections (with diarrhoea, intestinal parasites) or malaria. Where such infections are not lethal, evidence suggests that exposure to water related diseases, particularly helminths, still leads to irreversible growth faltering, lowered immunity and increased morbidity .Enteric infections increase risk and severity of under nutrition via a number of different mechanisms. There is increasing evidence for enteric infections to cause damage to the gut-lining leading to malabsorption, even in the absence of pathogenic indicators of disease. (UNICEF cited in Smith et al., 2005). Where there is a better

access to safe water and quality sanitation, the incidence of various illnesses will decline (Smith and Haddad, 2000). World Bank (2006) stated that improving access and quality of safe water not only reduces transmission of waterborne diseases but also protect women from huge work load to get safe water.

Lack of access to clean potable water and poor sanitation are also major public health problems in the northeast and Turkana, Kenya. In Mandera, a large portion of the population is currently obtaining water from unsafe sources (unprotected pans, contaminated rivers, lake). Treatment of water by boiling or purification is not common. Water is in short supply and in many areas has had to be trucked in. Poor hygiene is not surprisingly a significant issue. The great majority of the population does not have access to adequate sanitation. In Turkana, between 10 and 55 percent of households surveyed disposed of feces in an unhygienic manner. In North Eastern Province, 70 percent of waste was disposed of inappropriately (thrown outside). It is thus not surprising that infectious excreta-related diseases are common. In Turkana severe acute malnutrition is strongly associated with crowded settled areas (e.g. the central division where rates are extremely high) and poor hygiene and sanitation. Christiaensen and Alderman (2001) found possession of a tap and a flush toilet to have a positive effect on height. However, access to other sources of drinking water which are generally deemed safe such as public taps and protected wells were not found to positively effect on height. Similar results for underweight are also found by Woldemariam and Timotiwos, 2002; Alemu et al, 2005; b.

Women's age are important factors that affect maternal depletion, especially in high fertility countries. DHS surveys conducted in Burkina Faso, Ghana, Malawi, Namibia, Niger, Senegal, and Zambia show a greater proportion of mothers age 15-19 and 40-49 that exhibit chronic energy deficiencies (CED). A local study in Ethiopia also showed that women in the youngest age group (15-19) and women in the old stage group surveyed (45-49) are the most affected by under nutrition (Teller and Yimar, 2000).

Results on Erute IDP camp in Ugandans showed that there was a significant difference in age between women who had good nutritional status and those who had poor nutritional status ($p < 0.05$). Good nutritional status IDW tended to be much older, with a mean age of 42 years, than poor nutritional status IDW, whose average age was 20 years. Age has been used in various

agricultural production studies to proxy for experience in farming. Farmers who have more experience in agricultural production tend to have higher yields, and this is attributable to the great managerial skills gained over time. Kmenta (1971) carried out a study on age in agricultural production and observed that greater experience in farming is directly linked to higher agricultural production, which is also a key determinant of food security and nutrition in sub-Saharan Africa. Since some of the respondents had access to farms outside the camp, their experience in farming could have contributed to improved nutritional status. However, some researchers argue that age cannot be used as a proxy for experience in farming because a farmer can be old but may not necessarily have the required managerial aptitude in view of the fact he or she may have just taken up farming (Abdulai and Huffman, 2000).

2.4. Problems Caused by Women Malnutrition

Malnutrition worldwide includes a spectrum of nutrient-related disorders, deficiencies, and conditions such as intrauterine growth retardation, protein-energy malnutrition, iodine deficiency disorders, vitamin A deficiency, iron-deficiency anemia, and overweight/obesity and other diet-related non communicable diseases (Ratzan et al., 2000). It poses a variety of threats to women. It can lead to an onslaught of additional health complications, weakens women's ability to survive childbirth, makes them more susceptible to infections, and leaves them with fewer reserves to recover from illness and eventually even death. Poor nutrition is an obstacle to accelerated income growth. Moreover, failure to address malnutrition places a long-term drag on the entire economy. If malnutrition is not addressed in early childhood, subsequent interventions or economic prosperity, at best, will only partially reverse the consequences.

Illnesses associated with nutrient deficiencies have significantly reduced the productivity of women in less developed countries. It is difficult to determine exactly what proportion of those losses are due to maternal malnutrition, but Research indicates that 60 percent of deaths of children under age 5 are associated with malnutrition and children's malnutrition is strongly correlated with mothers' poor nutritional status. Problems related to anemia, for example, including cognitive impairment in children and low productivity in adults, cost US$5 billion a year in South Asia alone (Ransom and Elder, 2003).

Every year, more than 500,000 women worldwide die from complications arising from pregnancy and childbirth. Iron deficiency anemia among pregnant women has been suggested to cause about an estimated 111,000 maternal deaths each year. Economic consequences of iron deficiency anemia reveals that the annual per capita productivity loss due to iron deficiency is 4.19 US dollar or 1.9% of the gross domestic product for Bangladesh. Severe anemia places women at higher risk of death during delivery and the period following childbirth. Research suggests that even mild anemia puts women at greater risk of death. Iron deficiency and anemia cause fatigue, reduce work capacity, impairs immune function and make people more susceptible to infection. At age 15-44 years, the burden on iron deficiency anemia in developing countries in terms of Disability Adjusted Life Years(DALYs) per year is 7135 for women as against 4898 for men (Haseen, 2003).

Malnutrition in women leads to economic losses for families and countries because malnutrition reduces women's ability to work and can create worse effects that extend through generations. Countries where malnutrition is common must deal with its immediate costs, including reduced income from malnourished population, and face long-term problems that may be related to low birth weight, including high rates of cardiac disease and diabetes in adults. A report from Asia reveals that malnutrition reduces human productivity by 10% to 15% and gross domestic product by 5% to 10% (Haseen, 2003).

Maternal and child under nutrition account for 11% of the global burden of disease (Black et al., 2008). Maternal under nutrition are global problems with important consequences for survival, incidence of acute and chronic diseases, healthy development, and the economic productivity of individuals and societies. Maternal stature is a composite indicator representing genetic and environmental effects on the growing period of childhood of dying among children younger than 5 years born to the tallest mothers (≥160 cm) was 0.073 (95% CI 0.072–0.074) and to those born to the shortest mothers (<145 cm) was 0.128 (0.126–0.130). The corresponding absolute risk for a child being stunted was 0.194 (0.192–0.196) for the tallest mothers and 0.682 (0.673–0.690) for the shortest (The Maternal and Child Nutrition Study Group, 2013).

2.5. Nutritional Assessment in Women

Anthropometric measurements are used to construct indices for women malnutrition. Among four possible anthropometric indicators to assess women's chronic under nutrition(height, body mass index (BMI), weight and mid-arm circumference (MUAC) (Quinnin, 1999), BMI is considered to be the most suitable, objective anthropometric indicator of nutritional status of women. It was chosen because this anthropometric indicator, derived from measures of weight and height of individuals of both sexes, is consistently and highly correlated with body weight (or energy stores within the body) and is relatively independent of the height of the individual. A BMI < 18.5 kg/m² is widely used as a practical measure of chronic energy or hunger deficiency (CED), i.e., a "steady" underweight in which an individual is in energy balance irrespective of a loss in body weight or body energy stores (Khongsdier, 2005). The assessment is done by observing the deviations of the anthropometric measures from the normal standard and it cannot be used for pregnant women. Sphere guidelines recommend that BMI be adjusted for the ratio of sitting height to standing height, or *Cormic Index*, though this is not often done in practice.

The BMI, which incorporates both height and weight and provides a better measure of thinness and obesity than weight alone, is defined as weight in kilograms divided by the square of the height in meters (kg/m^2). For BMI, a cut off of 18.5 has been recommended for indicating chronic energy deficiency among non-pregnant women (ACC/SCN, 2000).

The use of BMI to identify malnutrition in women was proposed in 1986 by the IDECG. This group of experts defined "chronic energy deficiency"(CED)"... not as a prolonged continuing loss of body energy, but as a steady state at which a person is in energy balance although at a cost either in terms of risk to health or as an impairment of functions and health"(James et al. 1988).The World Health Organization defined under nutrition as BMI<18.5; well nutrition as 18.5≥BMI<25; over nutrition as25≥BMI<30; and obesity as BMI≥30 (WHO, 1998).

Research shows that there is a relationship between BMI and health outcome, with the greatest risks of ill-health associated with the higher and lowest BMI (Bray, 2003). In cases where height is difficult to measure, there are other parameters that can be used instead, such as the Demispan. If both height and weight are difficult to obtain, the mid-upper arm circumference (MUAC) can be used. MUAC in combination with clinical signs is often used to screen adults for admittance

to feeding centers. While cut-offs have been defined for BMI in women, but there is no international consensus on the cut-off points for classifying severe malnutrition in women using MUAC. Therefore, BMI is used as the outcome for this study.

2.6. Prevalence of women malnutrition

The importance of women must be addressed from birth to six months, exclusive breastfeeding can ensure that an infant receives relatively sufficient nutritional intake for health and development. In the short run, we must promote this practice followed by education on hygienic complimentary feeding. Community based nutrition programs and monthly growth-monitoring sessions are inclusive and effective ways to improve knowledge and subsequent care practices. In the long term, it is vital we develop the infrastructure necessary to increase access to education and to proper health services for our population.

Prevalence of low BMI (<18.5 kg/m2) in adult women has decreased in Africa and Asia since 1980, but remains higher than 10% in these two large developing regions. Latest anemia survey conducted in 2003 in Bangladesh shows that anemia prevalence is 33% and 45%among the non-pregnant non lactating women and pregnant women respectively. The Nigeria DHS 2003 reported 15 percent prevalence of chronic energy deficiency among women, ranging from 7 percent in the North Central to 23 percent in the North East and about 16 percent CED among rural women compared to 13 percent among urban women (Ajieroh, 2009).

The Nigeria food consumption survey has provided nutritional indicators for women of child-bearing age defined as women 16-35 years of age shows comparison data of women's BMI with the 2003 National Demographic and Health Survey. Nationally the prevalence of women with chronic energy deficiency (CED) as defined by BMI <18.5 was 4.6% with the highest provincial prevalence in the Northern Cape 16.7% followed by the Limpopo Province at 7.9% (Labadarios, et al., 2008).

3. DATA AND METHODOLOGY

3.1. Data Source

The dataset used in this study was taken from the Ethiopia Demographic and Health Survey (EDHS) conducted by central Statistics Agency (CSA) in 2011. The 2011 EDHS is a nationally representative survey of women aged 15−49 from 17,817 households from 624 clusters throughout Ethiopia, 187 in urban areas and 437 in the rural areas. The survey utilized a multistage cluster sample based on the 1994 Population and Housing Census sample frame and was designed to obtain and provide information on the basic indicators of the health and demographic variables of interest for the following domains: Ethiopia as a whole, urban and rural areas (each as a separate domain), and all geographic areas (nine regions namely: Tigray, Affar, Amhara, Oromiya, Somali, Benishangul-Gumuz, Southern Nations, Nationalities and Peoples (SNNP), Gambela and Harari regional states and two city administrations :Addis Ababa and Dire Dawa).

This multistage 2011 EDHS dataset is of hierarchical structure. The hierarchy for this study follows women as level-1, and regions as level-2. This means that individuals are nested in regions. From among the 17,817 households, 17,385 women were identified as eligible for the individual interview. Interviews were completed with 16,515 women, yielding a response rate of 95 percent. Thus, the analysis presented in this study based on 8,278non-pregnant and non-postpartum women (women who hadn't a birth in the three months preceding the survey).

3.2. Study Variables

The dependent and independent variables that were considered in this study were selected based on available similar studies and data on the subject.

3.2.1. The Dependent Variable

The dependent variable of this study is the nutritional status of women in Ethiopia. This thesis is intended to apply to women of reproductive age between 15 and 49 years. According to WHO reference, we use anthropometric index (i.e. body mass index) in-order to measure the nutritional status of women. Women who have normal nutritional status whose body mass index (BMI) of between 18.5-24.9 and BMI above 25 is over nutrition (obesity). In our study, the dependent variable, the nutritional status of women is classified as malnourished women (whose body mass index is below 18.5), and otherwise not malnourished women. Therefore, the outcome for i^{th} woman is represented by random variable Y_i with two possible values coded as 1and 0.so, Y_i will measured as dichotomous variable.

$$Y_i = \begin{cases} 1, if\ ith\ woman\ is\ malnourished \\ 0, BMI\ is\ above\ 18.5 \end{cases}$$

3.2.2. Independent Variables

Some of the common factors that are expected to affect the nutritional status of women in Ethiopia were listed below for analysis purpose.

Variables	Description	Categories
PRS	Place of residence	0=Rural 1=Urban
EDL	Educational level	0= No education 1=Primary 2= Secondary $^{+}$
PEDL	Partner's Education level	0= No education 1=Primary

		2= Secondary $^{+}$
ECOS	Economic Status	0= Poor 1= Medium 2= Rich
SDW	Source of Drinking Water	0= Non improved source(surface water, tanker truck, unprotected well, rain water, other's) 1= Improved source(piped into dwelling, piped to yard, public tap, protected well, bottled water)
SAN	Toilet Facilities	0= No facilities (field toilet, hanging toilet, others) 1=Have facilities (Pit toilet, Flush toilet)
AGE	Age of women	0=15-24 1=25-34 2=35-49
EMPS	Employment Status	0=Unemployed 1= Employed
PEMPS	Partner's Employment Status	0=Unemployed

		1=Agricultural work 2=Non- agricultural work
MAR	Marital Status	0=Never married or separated 1=Married
REG	Region	1= Tigray 2=Affar 3=Amhara 4=Oromiya 5=Somali 6=Ben-Gumuz 7=SNNP 8=Gambela 9=Harrari 10=Addis Ababa, 11=Dire Dawa

3.3. Methodology

3.3.1. Logistic Regression Analysis

Logistic regression is a popular modeling approach when the dependent variable is dichotomous or polytomous. This model allows one to predict the log odds of outcomes of a dependent variable from a set of variables that may be continuous, discrete, categorical, or a mix of any of these. Hosmer and Lemeshow (2000) have described logistic regression focusing on its theoretical and applied aspect.

Often the outcome variable in social data is, in general not continuous, instead is binary. In such a case, binary logistic regression is a useful way of describing the relationship between one or more independent variables and a binary outcome variable that has only two possible values. Indeed, a generalized linear model is used for binary logistic regression. The most attractive feature of a logistic regression model is that it neither assumes linearity in the relationship between the covariates and the outcome variable, nor does it require normally distributed variables. It also does not assume homoscedasticity and in general has less stringent requirements than linear regression models. Thus logistic regression is used in a wide range of applications leading to binary dependent data analysis (Hilbe, 2009; Agresti, 2007).

In instances where the independent variables are categorical or a mix of continuous and categorical, logistic regression analysis is preferred to discriminant analysis (Agresti, 2007). The assumptions required for statistical tests in logistic regression are far less restrictive than those for ordinary least squares regression. There is no formal requirement for multivariate normality, homoscedasticity, or linearity of the independent variables within each category of the response variable. However, the assumptions that apply to logistic regression model include: meaningful coding, inclusion of all relevant and exclusion of all irrelevant variables in the regression model and low error in the explanatory variables.

3.3.1.1. Model

In the terminology of logistic regression analysis the odds of a success is defined to be the ratio of the probability of a success to the probability of a failure.

Let Y be an nx1 vector of response variable with $y_i = 1$ if the i^{th} woman is malnourished and $y_i=0$ if the i^{th} woman is not malnourished, X is an n x (k+1) design matrix of explanatory variables, β is a (k+1) x1 vector of parameters. The data layout for X is given as follows.

$$X=\begin{bmatrix} 1 & x_{11} & x_{12} & \cdots & x_{1k} \\ 1 & x_{21} & x_{22} & \cdots & x_{2k} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ 1 & x_{n1} & x_{n2} & \cdots & x_{nk} \end{bmatrix}$$

X without the leading column of 1s, is termed as predictor data matrix. Let the conditional probability that the outcome is present (probability of success) be given by:

$$\Pi = p(Y = 1|X) = \frac{\exp(\beta_0+\beta_1 x_1+\cdots+\beta_k x_k)}{1+\exp(\beta_0+\beta_1 x_1+\cdots+\beta_k x_k)} = \frac{\exp(X\beta)}{1+\exp(X\beta)} \quad (3.1)$$

Using (3.1), we obtain the odds of success as

$$odds(Y = 1) = \frac{}{1-} = \exp(X\beta) \quad (3.2)$$

In logistic regression analysis, it is assumed that the explanatory variables affect the response through a suitable transformation of the probability of the success. This transformation is a suitable link function of π, and is called the logit-link, which is defined as:

$$logit(\pi) = log\left(\frac{}{1-}\right) = \log\left(e^{\beta_0+\beta_1 x_1+\beta_2 x_2+\cdots+\beta_k x_k}\right) = \log\left(e^{X\beta}\right) \quad (3.3)$$

The transformed variable, denoted by logit (π) is the log-odds and is related to the explanatory variables as:

$$logit(\pi) = \eta(x) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k = X\beta \quad (3.4)$$

where $\beta' = (\beta_0, \beta_1, \beta_2 \ldots \beta_k)$ are the model parameters and $X' = (x_0, x_1 \ldots x_k)$ with $x_0 = 1$, are explanatory variables.

The above equations give suitable representations of the success probability, odds, and log-odds. Indeed, these representations facilitate interpretations of parameter estimates. The parameter refers to the effect of x_i on the log odds that $y_i = 1$, controlling the other x's in the model.

3.3.1.2. Parameter Estimation

The most commonly used method of estimating the parameters of a logistic regression model is the method of Maximum Likelihood (ML). Mainly for this reason the ML method based on Newton-Raphson iteratively reweighted least square algorithm becomes more popular with researchers (Ryan, 1997). The sample likelihood function is, in general defined as the joint probability function of the observations and parameters, for a sample of size n with observations (y_1, y_2 … y_n) and each observation follows a Bernoulli distribution so, the probability mass function of each sample observation is:

$$f_i(y_i) = \pi_i^{y_i}(1-\pi_i)^{1-y_i} \quad (3.5)$$

$y_i = 0$ or 1 and i=1, 2,…, n

Since the observations are assumed to be independent, the likelihood function is obtained as the product of the terms given in expression (3.5) as follows:

$$L(\beta) = \prod_{i=1}^{n} \pi_i^{y_i} [1-\pi_i]^{1-y_i} \quad (3.6)$$

The maximum likelihood estimate is the parameter value of β that maximizes the likelihood function. However, it is easier mathematically to work with the log likelihood function. The log likelihood is:

$$l(\beta) = \ln[L(\beta)] = \sum_{i=1}^{n} y_i ln\left(\frac{\pi_i}{1-\pi_i}\right) + \sum_{i=1}^{n} \ln(1-\pi_i) \quad (3.7)$$

To find the value of β that maximizes L (β) we differentiate L (β) with respect to β and set the resulting expressions equal to zero. These equations, known as the likelihood equations, are:

$$\sum_{i=1}^{n}[y_i - \pi_i] = 0 \quad (3.8)$$

And

$$\sum_{i=1}^{n} x_i[y_i - \pi_i] = 0 \quad (3.9)$$

For logistic regression the expressions in equation (3.9) are nonlinear in β and thus require special methods for their solution. These methods are iterative in nature and have been programmed into available logistic regression software. As such, it represents the fitted or

predicted value for the logistic regression model. An interesting consequence of equation (3.9) is that

$$\sum y_i = \sum \hat{\pi}_i \qquad (3.10)$$

That is, the sum of the observed values of y is equal to the sum of the predicted (expected) values.

3.3.1.3. Statistical Tests of Individual Predictors

The statistical significance of individual regression coefficients is tested using the Wald and Score chi-square statistic. The Wald statistic is a test which is commonly used to test the significance of the individual logistic regression coefficients for each independent variable (that is, to test the null hypothesis in logistic regression that a particular logit coefficient is zero i.e. H_o: $\beta_i=0$ against H_1: $\beta_i \neq 0$, i=1,2,...,k.

The Wald test is based on the behavior of the log-likelihood function at the ML estimate $\hat{\beta}$, having chi-squared form. The standard error of the estimate depends on the curvature of the log-likelihood function at the point where it is maximized, with greater curvature giving smaller SE values. For a dichotomous dependent variable, the Wald statistic is:

$$W = \left[\frac{\hat{\beta}}{SE(\hat{\beta})}\right]^2 \qquad (3.11)$$

Under the null hypothesis for large sample size, this statistic has an approximate chi-square distribution with one degree of freedom.

3.3.1.4. Overall Model Evaluation

A logistic model is said to provide a better fit to the data if it demonstrates an improvement over the intercept-only model (also called the null model). An intercept-only model serves as a good baseline because it contains no predictors. Consequently, all explanatory variables are added to the model. An improvement over this baseline is examined by using three inferential statistical tests: the likelihood ratio, score, and Wald tests.

The Likelihood Ratio (LR) test is performed by estimating two models and comparing the fit of one model to the fit of the other. Removing predictor variables from a model will almost always make the model fit less well, but it is necessary to test whether the observed difference in model fit is statistically significant. The likelihood ratio test does this by comparing the log likelihoods of the two models, if this difference is statistically significant, then the less restrictive model (the one with more variables) is said to fit the data significantly better than the more restrictive model. If one has the log likelihoods from the models, the likelihood ratio test is fairly easy to calculate. The likelihood ratio test is performed to test the overall significance of all coefficients in the model on the basis of test statistic:

$$G = [(-2lnL_0) - (-2lnL_1)] \quad (3.12)$$

where, L_0 is the likelihood of the null model and L_1 is the likelihood of the saturated model. The statistic G is distributed chi-squared with degrees of freedom equal to the difference in the number of degrees of freedom between the two models.

3.3.1.5. Hosmer-Lemeshow Goodness-of-Fit test

The Hosmer-Lemeshow test is one of the recommended tests for overall fit of a binary logistic regression model. This goodness-of-fit statistic is used to assess the fit of a logistic regression model. Hosmer and Lemeshow's goodness of fit test divides subjects into deciles based on predicted probabilities and then computes a chi-square from observed and expected frequencies. Using this grouping strategy, the Hosmer-Lemeshow goodness-of-fit statistic, $\hat{C}$ is obtained by calculating the Pearson chi-square statistic from the gχ2 table of observed and estimated expected frequencies. A formula defining the calculation of $\hat{C}$ is as follows:

$$\hat{C} = \frac{\sum(O_k - E_k)^2}{V_k} \quad (3.13)$$

where E_k= n P_k, V_k = nP_k (1-P_k), 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 in the k^{th} group, and $V_k$is a variance correction factor for the k^{th} group. This statistic has Ho: Model fit well vs H1: Not Ho. If p-value of the Hosmer- Lemeshow goodness-of-fit test statistic is $X^2_{0.05}$ (g-2) is greater, we will not reject the null hypothesis that there is no difference between observed and model-predicted values, implying that the model estimates are adequate to fit the data.

3.3.1.6. Model Diagnostics

Regression model building is often an iterative and interactive process. The first model we try may prove to be inadequate. Regression diagnostics are used to detect problems with the model and suggest improvements.

There are three ways that an observation can be considered as unusual, namely outlier, influence and leverage. In logistic regression, observations whose values deviate from the expected range and produce extremely large residuals and may indicate a sample peculiarity are called outliers. These outliers can unduly influence the results of the analysis and lead to incorrect inferences. An observation is said to be influential if removing the observation substantially changes the estimate of coefficients. An observation with an extreme value on a predictor variable is called a point with high leverage. Leverage is a measure of how far an independent variable deviates from its mean. In fact, the leverage indicates the geometric extremeness of an observation in the multi-dimensional covariate space. These leverage points can have an unusually large effect on the estimate of logistic regression coefficients (Cook, 1998).

To identify if an observation is outlier or influential, the following rules of thumbs were employed in this study.

Leverage Values (Hat Diag) is a measure of how far an observation is from the others in terms of the levels of the independent variables (not the dependent variable). Observations with leverage values larger than one are considered to be potentially highly influential (Belsley et al., 1980). The formula is:-

$$h_i = \frac{1}{n} + \frac{(x_i - \bar{x})^2}{S_{xx}} \qquad (3.14)$$

where:- h_i= Leverage value, n= Number of observations and S_{xx} is Standard error

DFBETAS is a measure of how much an observation has affected the estimate of a regression coefficient (there is one DFBETA for each regression coefficient, including the intercept). Values larger than $\frac{2}{\sqrt{n}}$ in absolute value are considered highly influential. The formula is :-

$$\text{DFBETAS}_{ij} = \frac{\hat{\beta}_j - \hat{\beta}_{j(i)}}{\text{SE}_{\hat{\beta}_{j(i)}}} \qquad (3.15)$$

Cook's D is a measure of aggregate impact of each observation on the group of regression coefficients, as well as the group of fitted values. In logistic regression, a case is identified as influential if its Cook's distance is greater than 1.0 (Hosmer- Lemeshow, 2000). It can be calculated by:-

$$D_i = \frac{r_i^2 \, Var(\hat{y}_i)}{p \, Var(e_i)} = \frac{r_i^2 \; h_{ii}}{p(1-h_{ii})} \qquad (3.16)$$

where:- D_i = Cook's distance, r_i^2 = Standardized residual, h_{ii} = Leverage and P= Number of predictors.

3.3.2. Multilevel Logistic Regression Model

A multilevel logistic regression model, also referred as a hierarchical model in the literature. It can account for lack of independence across levels of nested data (e.g., women nested within regions). Standards logistic regression assumes that all experimental units (in this case, women) are independent in the sense that any variables affecting the dependent variable have the same effect in all regions. Multilevel modeling relaxes this assumption and allows these variables' effects to vary across regions.

Hierarchical models are statistical models that can be used to analyze nested sources of variability in hierarchical data, taking account of the variability associated with each level of the hierarchy. These models have also been referred to as multilevel models, mixed models, random coefficient models, and covariance component models (Breslow and Clayton, 1993; Longford, 1993; Snijders and Bosker, 1999; Hox, 2002; Goldstein, 2003).

As mentioned above, multilevel logistic regression analysis is a methodology for analysis of data with complex patterns of variability, with a focus on nested sources of variability on multiple categories. For this study the variation of malnutrition of women within regions means that not only unexplained variation between women but also unexplained variation between regions. This can be expressed by statistical models with random coefficients.

3.3.2.1. Two Level Model

For simplicity of presentation two-level models are used for this study, i.e., models accounting for women-level and regional-level effects. In this data structure, level-1 is the women level and

level-2 is the regional level. Within each level-2 unit there are n_j woman in the j^{th} region. We further simplify the presentation by assuming there is women-level predictor and regional-level factor.

To provide a familiar starting point, we first consider a two-level model for binary outcomes with a single explanatory variable. Conceptually, the basic multilevel model for a binary response is equivalent to model (3.2) except for the notation in the outcome variable. Suppose we have data consisting of women (level one) grouped into regions (level two). Let Y_{ij} be the binary response for women i in region j and X_{ij}, an explanatory variable at the women level. We define the probability of the response equal to one as P_{ij}= Pr (y_{ij} = 1) and let P_{ij} be modeled using a logit link function. The standard assumption is that y_{ij} has a Bernoulli distribution. Then the two-level model can be written as

$$log\left[\frac{P_{ij}}{1-P_{ij}}\right] = \beta_0 + \beta_1 X_{ij} + U_j \qquad (3.17)$$

where $U_j \sim IID(0, \sigma_u^2)$. U_j is the random effect at level two. Without U_j, Equation (3.17) would be a standard logistic regression model. Conditional on U_j, the y_{ij} is assumed to be independent. The model (3.17) is often described as follows.

$$logit(P_{ij}) = log\left[\frac{P_{ij}}{1-P_{ij}}\right] = \beta_{0j} + \beta_i X_{ij} \qquad \text{[Level 1 model]}$$

And, $\beta_{oj} = \beta_0 + U_j$ [Level 2 model]

3.3.2.2. Heterogonous Proportion

For the proper application of multilevel analysis, the first logical step is to test heterogeneity of proportions between groups. The most commonly used test statistic to check for heterogeneity of proportions between groups is the chi-square. To test whether there are indeed systematic differences between the groups, the well-known chi-square test can be used. The test statistic of the chi-squared test for contingency table is often given in familiar form:

$$X^2 = \frac{\sum_i (O-E)^2}{E} \qquad (3.18)$$

where O is the observed and E is the expected counts in the cell of contingency table. It can also be written as:

$$X^2 = \sum_{j=1}^{g} n_j \frac{(\hat{p}_j - \hat{p}_.)^2}{\hat{P}_.(1-\hat{P}_.)} \quad (3.19)$$

where the group average, $\hat{p}_j = \frac{1}{n_j}\sum_{i=1}^{n_j} Y_{ij}$ is the proportion of malnourished women in region j which is an estimate for the group-dependent probability P_j. Similarly, the overall average $\hat{P}_. = \bar{Y}_{..} = \frac{1}{n}\sum_{j=1}^{g}\sum_{i=1}^{n_j} Y_{ij}$ here is the overall proportion of malnourished women with

$n = \sum_{j=1}^{g} n_j$.

The decision will be based on the chi-square distribution with (g-1) degrees of freedom. This chi-square distribution is an approximation valid if the expected number of success and of failures in each group, $n_j p_{.j}$and $n_j(1 - p_{.j})$ respectively, all are at least 1 while 80 percent of them are at least 5 (Agresti, 2007).

Estimation of between and within group variance: The theoretical variance between the group dependent probabilities, i.e., the population value of Var (P_j), can be estimated by:

$$\hat{\tau}^2 = S^2_{between} - \frac{S^2_{within}}{\tilde{n}} \quad (3.20)$$

where $\tilde{n}$ is given by :

$$\tilde{n} = \frac{1}{g-1}\left[n - \frac{\sum_{j=1} n_j^2}{n}\right] = \bar{n} - \frac{S^2(n_j)}{g\bar{n}} \text{And} n = \sum_{j=1}^{g} n_j$$

For dichotomous outcome variables, the observed between-groups variance is closely related to the chi-squared test statistic (3.16). They are connected by the formula.

$$S^2_{between} = \frac{\hat{P}_.(1-\hat{P}_.)}{\hat{n}(g-1)} X^2 \quad (3.21)$$

The within-group variance in the dichotomous case is a function of the group averages, via,

$$S^2_{within} = \frac{1}{n-g}\sum_{j=1}^{g} n_j p_{.j}\,(1 - p_{.j}) \quad (3.22)$$

3.3.2.3. The Empty Two-Level Model

The empty two-level model for a dichotomous outcome variable refers to a population of groups (level-two units, i.e. regions) and specifies the probability distribution for group-dependent probabilities without taking any explanatory variables into account. This model only contains random groups and random variation within groups. It can be expressed with logit link function as follows.

$$logit(P_j) = \beta_0 + U_{0j} \quad (3.23)$$

$$U_{oj} \sim IID(0, \sigma_0^2)$$

where β_0 the population average of the transformed probabilities and U_{0j} is the random deviation from this average for group j.

3.3.2.4. The Random Intercept Logistic Regression Model

In the random intercept logistic regression model, the intercept is the only random effect meaning that the groups differ with respect to the average value of the response variable. It represents the heterogeneity between groups in the overall response.

The logistic random intercept model expresses the log-odds, i.e. the logit of P_{ij}, as a sum of a linear function of the explanatory variables and a random group-dependent deviation U_{0j}. That is,

$$logit(P_{ij}) = \log\left(\frac{P_{ij}}{1 - P_{ij}}\right) = \beta_{oj} + \beta_1 X_{1ij} + \beta_2 X_{2ij} + \cdots + \beta_k X_{kij}$$

$$logit(P_{ij}) = \beta_{oj} + \sum_{h=1}^{k} \beta_h X_{hij} \quad (3.24)$$

where:- The intercept term β_{oj} is assumed to vary randomly and is given by the sum of an average intercept β_o and group- dependent deviations U_{0j}. That is:

$$\beta_{oj} = \beta_o + U_{oj}$$

As a result

$$logit(P_{ij}) = \beta_o + \sum_{h=1}^{k} \beta_h X_{hij} + U_{oj} \quad (3.25)$$

$$U_{oj} \sim IID(0, \sigma_0^2)$$

where is the log-odds that y = 1 when x = 0 and u = 0, is the effect on log-odds of dependent variable in same group (same value of u), exp (β_h) is an odds ratio, comparing odds for individuals in the same group. U_{0j} is the effect of being in group j on the log-odds that y = 1 also known as a level 2 residual, σ_0^2 is the level 2 (residual) variance, or the between-group variance in the log-odds that y = 1 after accounting for x.

Note that the first part of the left-hand side of equation (3.25), incorporating the regression coefficients, $\beta_o + \sum_{h=1}^{k} \beta_h X_{hij}$ is the fixed part of the model, because the coefficients are fixed. The remaining part,U_{oj} is called the random part of the model.

3.3.2.5. The Random Coefficient Model

So far, we have allowed the probability of malnutrition to vary across regions, but we have assumed that the effects of the explanatory variables are the same for each region. We will now modify this assumption by allowing the difference between explanatory variables within a region to vary across regions. To allow for this effect, we will need to introduce a random coefficient for those explanatory variables. So, a random coefficient model represents heterogeneity in relationship between the response and explanatory variables.

As mentioned above, the response variable in this study, the nutritional status of women was binary. Therefore the statistical model used in this analysis was the two-level random coefficient multilevel regression model. The model, with p level-1 predictors and q level- 2 predictors, can be expressed as:

$$logit(\pi_{ij}) = log\left[\frac{\pi_{ij}}{1-\pi_{ij}}\right] = \beta_{oj} + \sum_{h=1}^{p} \beta_{hj} X_{hij} + \sum_{h=1}^{q} U_{hj} X_{hij} \qquad (3.26)$$

where:-

$\beta_{oj} = \beta_o + U_{oj}$, i=1,2,3...,$n_j$, j=1,2,3,...,11 and h=1,...,k.

Now the above equation is written as

$$logit(\pi_{ij}) = log\left[\frac{\pi_{ij}}{1-\pi_{ij}}\right] = \beta_0 + \sum_{h=1}^{p} \beta_h X_{hij} + U_{oj} + \sum_{h=1}^{q} U_{hj} X_{hij} \qquad (3.27)$$

$$Y_{ij} \sim Binary(\pi_{ij}), U_{oj} \sim Normal(0, \sigma_0^2)$$

The first part of equation (3.24),$\beta_0 + \sum_{h=1}^{p} \beta_h X_{hij}$ is called the fixed part of the model. the second part $U_{oj} + \sum_{h=1}^{q} U_{hj} X_{hij}$ is called the random part.

Y_{ij} is the value of the response variable for the i^{th} woman in the j^{th} region. X_{hij} is the value of individual-level explanatory variable X_p for the i^{th} woman in the j^{th} region. X_{hij} is the value of region-level explanatory variable X_q for the j^{th} region. U_{0j} is the region-level residual of the j^{th} region. It is a random effect that represents the discrepancy between β_0 and the true intercept of the j^{th} region and n_j is the number of women respondents in the j^{th} region.

3.3.2.6. Intra-class Correlation Coefficient (ICC)

ICC is the degree of resemblance between level one units belonging to the same group. It is an indication of the proportion of variance at the second level (region) and it can also be interpreted as the expected (population) correlation between two randomly chosen individuals within the same group (Joop, 2010).

In two- level model, the ICC is calculated in the intercept only model. This model can be derived from "Eq. (3.23)" by excluding all explanatory variables, which results in the following equation: $logit(p_j) = \beta_o + U_{oj}$ .The ICC is then calculated based on the following formula:

$$ICC = \frac{\sigma_{uo}^2}{\sigma_{uo}^2 + \sigma_e^2} \quad (3.28)$$

where, σ_e^2 is variance of individual (lower) level units.

Since the logistic distribution for the level one residual variance implies a variance of (Snijders and Bosker, 1999) and this formula can be reformulated as:

$$ICC = \frac{\sigma_{uo}^2}{\sigma_{uo}^2 + 3.29} \quad (3.29)$$

3.3.2.7. Parameter Estimation

The estimation method of most of the statistical model are well established. But this is not true for multilevel models for binary data. Parameter estimation for multilevel logistic model is not straightforward like the methods for simple logistic regression model. The most common methods for estimating multilevel logistic models are Marginal Quasi Likelihood (Goldstein,

1991; Goldstein and Rasbash, 1996), Penalized Quasi Likelihood (Laird, 1978; Breslow and Clayton, 1993), numerical procedure (Stiratelli, Laird and Ware, 1984) and bootstrap and Gibbs sampler (Zeger and Karim, 1991). The numerical integrations approach and Laplace approximation seem to produce statistically more satisfactory estimates than MQL and PQL approaches. They have additional advantage that the deviance produced is reliable, in contrast to the deviance produced by the MQL and PQL methods (Snijders and Bosker, 1999).

3.3.2.8. Significance Testing in Multilevel Regression

As with ordinary least squares regression or logistic regression, we can consider significance tests for individual estimates, such as intercepts, slopes, and their variances, as well as whether the full model accounts for a significant amount of variance in the dependent variable. In between, there is also the possibility of determining whether of subset of predictors contribute significantly (Newsom, 2011).

3.3.2.8.1. Significance Testing for Fixed Effects

The fixed effects in multilevel regression are typically tested in a familiar way, by creating a ratio of the intercept or slope estimate to the estimate of the standard error (Newsom, 2011). The usual null hypothesis test is whether the coefficient, either intercept or slope, is significantly different from zero (i.e., is the population value zero or not). This kind of ratio, usually distributed as a *z* or *t*, is used in many statistical tests (Raudenbush and Bryk, 2002).

$$t = \frac{\hat{\beta}_h}{S.E(\hat{\beta}_h)} \qquad (3.30)$$

where $\hat{\beta}_h$ is either the intercept or slope coefficient and S.E. ($\hat{\beta}_h$) is the standard error estimate.

In SPSS, STATA and MLwin fixed effects tests involve the same ratio of the estimate to the standard error estimate, but significance is determined by the normal curve, so it is considered a z-test. The z-test is often referred to as a "Wald" test.

3.3.2.8.2. Significance Testing for Random Effects

Random effects tests examine hypotheses about whether the variance of intercept or slopes (or their covariance) is significantly different from zero. The tests of variances and covariance are made using a Wald z-test and chi-square test. The Wald test for variances is simply a ratio of the

variance estimate divided by the standard error estimate. Significance tests of variances (but not covariance) using this approach should be interpreted after dividing the P-Value from the output in half (i.e., as a one-tailed test; Snijders & Bosker, 1999).

3.3.2.9. Goodness of Fit Test

It is useful to be able to judge whether a model is a good fit to the data. For this study, test of goodness of fit were employed using the deviance. The maximum likelihood procedure produces a statistic called the deviance, which indicates how well the model fits the data. The test compares the deviance (-2 log likelihood) of two models by subtracting the smaller deviance (model with more parameters) from the larger deviance (model with lower parameters). The difference is a chi-square test with the number of degrees of freedom equal to the number of different parameters in the two models. Similarly, the overall model evaluation is also examined using Akaike Information Criteria (AIC) and Schwartz Information Criteria (BIC). The smaller the value, the better of the model will be.

3.3.2.10. Model Diagnostics

It is of interest to obtain the residual values from the estimated multilevel model. Plots are a good way to examine the residuals. But in multilevel logistic regression, many different residual plots can be used. For this study, the fitted model was checked for possible presence of outliers and influential values in a similar fashion with standard logistic model. But additionally, the presence of outliers and influential observation were examined for level two. Leverage and influence value greater than one is considered as an influential observation for both level one and level two.

4. STATISTICAL DATA ANLAYSIS

The data analysis was done using STATA version 11, SPSS version 20 and MLwiN statistical packages. The results of the analysis are divided into the following sections: descriptive analysis, logistic regression analysis and multilevel logistic regression analysis. These results are presented below.

4.1. Results of Descriptive Analysis

The major factors which characterize the respondent with malnourished are presented in Table 4.1 below. The total number of women covered in the present study were 8,278. Among these, 2,378(28.7%) were malnourished whereas 5,900(71.3%) were not malnourished at the date of the survey.

Table 4.1 Results of Descriptive Analysis

		Malnourished				
Variables	**Categories**	**Yes**	**Percentage**	**No**	**Percentage**	**Total**
Region	Tigray	341	36.8	585	63.2	926
	Affar	327	46.3	380	53.7	707
	Amhara	280	24.9	844	75.1	1124
	Oromiya	297	26.8	811	73.2	1108
	Somali	148	32.8	303	67.2	451
	Ben-Gumuz	184	27.1	494	72.9	678
	SNNP	213	20.9	807	79.1	1020
	Gambela	303	47.2	339	52.8	642
	Harrari	112	21.2	416	78.8	528
	Addis Ababa	50	8.4	548	91.6	598
	Dire Dawa	123	24.8	373	75.2	496
Age						
	15-24	413	29.5	987	70.5	1400
	25-34	918	27.4	2428	72.6	3346
	35-49	1047	29.6	2485	70.4	3532

Type of Place of Residence						
	Rural	2150	34.4	4091	65.6	6241
	Urban	228	11.2	1809	88.8	2037
Education Levels						
	No Education	1742	31.9	3723	68.1	5465
	Primary	558	26.3	1565	73.7	2123
	Secondary+	78	11.3	612	88.7	690
Source of Drinking Water						
	Non-Improved Source	1500	40	2251	60	3751
	Improved Source	878	19.4	3649	80.6	4527
Toilet Facilities						
	No Facilities	1534	40	2303	60	3837
	Have Facilities	844	19	3597	81	4441
Economic status						
	Poor	1274	37	2169	63	3443
	Medium	376	30.4	861	69.6	1237
	Rich	728	20.2	2870	79.8	3598
Marital Status						
	Unmarried	358	26.4	999	73.6	1357
	Married	2020	29.2	4901	70.8	6921
Partner's Education Level						
	No Education	1411	33.5	2805	66.5	4216
	Primary	741	26.7	2033	73.3	2774
	Secondary+	226	17.5	1062	82.5	1288

Partner's Occupation						
	Did not Work	58	36.2	102	63.8	160
	Agricultural	1766	32.3	3695	67.7	5461
	Non-Agricultural	554	20.9	2103	79.1	2657
Women Occupation						
	Has no Work	1547	30.8	3475	69.2	5022
	Has work	831	25.5	2425	74.5	3256

The proportion of malnourished women varied from one region to another region with the highest proportion (47.2%) of malnutrition recorded in Gamebela followed by Afar (46.3%) and Somali (32.8%). However, the least proportion of malnutrition was observed in Addis Ababa (8.4%) followed by SNNP (20.9%) and Harrari (21.2%).While the proportion of malnourished women also differs with their age groups. For instance, higher proportion of malnutrition was observed for women with age group 35-49 years (29.6%) and the lowest proportion was found in the age group between 25-34 years (27.4%).Similarly, malnourished women differs by type of place of residence. Higher numbers of malnourished women (34.4 %) resided in rural areas, and small numbers resided in urban areas (11.2%).

Table 4.1 also reveals that the proportion of malnourished women varies by their educational levels. The highest percentage of malnourished women was observed in women who have no education (31.9%) as opposed to the lowest percentage of malnutrition which was recorded for women who have secondary and above education level (11.3%). Similarly, we observed that the nature of malnutrition of women varies by source of drinking water and toilet facilities. The highest percentage of women malnutrition was observed for women who used non- improved water source (40%) and have no toilet facilities (40%) as opposed to the lowest percentage of malnutrition which was recorded for women who used improved water source (19.4%) and have toilet facilities (19%).

Malnutrition of women also varies according to economic and marital status of women. A higher percentage of women malnutrition was observed in poor women (37%) and married women (29.2%) as opposed to the lowest percentage of malnutrition was observed for rich women (20.2%) and unmarried women (26.4%). Also higher percentage of malnourished women was observed in women who have no current work (30.8%) as opposed to the lowest percentage of malnutrition was observed on women who have current work (25.5%).

Women malnutrition also varies by partner's education level and occupation. A higher percentage of malnourished women was observed in women who have uneducated partner's (33.5%) and partners who have no current work (36.2%) as opposed to the lowest percentage of malnutrition which was observed on the secondary and above education level of partner's(17.5%) and partner's who have non-agricultural work(20.9%)

4.2. Results of Logistic Regression Analysis

In this section, the logistic regression analysis results obtained by using stepwise inclusion of variables, overall model evaluation, statistical tests of individual predictors and goodness-of-fit statistics are presented and also we identify statistically significant predictor variables and determine the direction of relationship to the dependent variable.

Table 4.2 Results of maximum likelihood estimates of parameters

Variables	Coefficient	Std. Err.	Z	P>z	Odds Ratio	[95% Conf. Interval]	
Age				**0.0530**			
15-24	-.1703789	.0772164	-2.21	0.027*	.8433452	-.3217203	-.0190375
25-34	-.103907	.0581689	-1.79	0.074	.9013091	-.2179159	.0101019
35-49(Ref)							
Region				**0.000***			
Tigray	.2106201	.1355292	1.55	0.120	1.234443	-.0550123	.4762524
Affar	.3031351	.1417075	2.14	0.032*	1.354097	.0253935	.5808767
Amhara	-.4754732	.1366795	-3.48	0.001*	.6215909	-.7433602	-.2075862
Oromiya	-.4201633	.1358232	-3.09	0.002*	.6569395	-.686372	-.1539547
Somali	-.0822432	.1561711	-0.53	0.598	.921048	-.388333	.2238467
Ben Gumuz	-.2834327	.1464736	-1.94	0.053	.7531938	-.5705157	.0036503
SNNP	-.6635825	.14227	-4.66	0.000*	.515003	-.9424266	-.3847383
Gambela	.5896883	.1427414	4.13	0.000*	1.803426	.3099203	.8694562
Harrari	-.2336209	.1596562	-1.46	0.143	.7916619	-.5465412	.0792995
Addis Ababa	-.4846453	.1934501	-2.51	0.012*	.6159156	-.8638005	-.10549
Dire Dawa(Ref)							

Place of Residence				**0.000***			
Rural	1.255848	.1035304	12.13	0.000*	3.510815	1.052932	1.458764
Urban(Ref)							
Education Level				**0.003***			
No Education	.1607617	.1576714	1.02	0.308	1.174405	-.1482686	.4697919
Primary	.3553887	.1514163	2.35	0.019*	1.426735	.0586183	.6521591
Secondary+(Ref)							
Source of Drinking Water				**0.000***			
Non-Improved Source	.6670637	.0627668	10.63	0.000*	1.948508	.5440431	.7900843
Improved Source(Ref)							
Toilet Facilities				**0.000***			
No Facilities	.5200308	.065507	7.94	0.000*	1.682079	.3916393	. 6484222
Have Facilities(Ref)							
Economic status				**0.003***			
Poor	-.2604887	.0776736	-3.35	0.001*	.7706749	-.4127262	-.1082512
Medium	-.1352009	.0872267	-1.55	0.121	.8735404	-.306162	.0357603
Rich(Ref)							
Marital Status				**0.420**			
Unmarried	-.0598001	.0742156	-0.81	0.420	.9419528	-.2052599	.0856597
Married(Ref)							
Partner's Education Level				**0.2839**			
No Education	.1805186	.113756	1.59	0.113	1.197838	-.042439	.4034762
Primary	.1411506	.1075333	1.31	0.189	1.151598	-.0696108	.351912
Secondary+(Ref)							
Partner's Occupation				**0.000***			
Did not Work	-.0327939	.1930357	-0.17	0.865	.967738	-.411137	.3455491
Agricultural Work	-.3161091	.0806387	-3.92	0.000*	.7289799	-.4741581	-.1580601
Non-Agricultural Work(Ref)							
Occupation				**0.022***			
Has no Work	-.1319996	.0574146	-2.30	0.022*	.8763413	-.2445303	-.019469
Has Work(Ref)							
_cons	-.9514953	.191841	-4.96	0.000*		-1.327497	-.5754939

*significant (p<0.05), Ref=Reference category

A negative sign in column labeled "Coefficient" indicates an inverse relationship of explanatory variable with the log odds of the dependent variable. In contrast a positive coefficient column labeled "Coefficient" indicates a positive relationship to the log odds of the dependent variable.

The statistical significance of individual regression coefficients is tested using the Wald chi-square statistic. According to Table 4.2 region, place of residence, education levels, source of drinking water, toilet facilities, economic status, occupation and partner's occupation were found to be significant predictors of malnutrition at 5% level of significance. Thus, the estimated model is given by:

$$logit(\hat{P}) = \beta_o + \sum_{i=1}^{11} \beta_{1i}\, RW_i + \sum_{j=0}^{1} \beta_{2j}\, PRW_j + \sum_{k=0}^{2} \beta_{3k} EDW_k + \sum_{l=0}^{1} \beta_{4l} SDW_l + \sum_{m=0}^{1} \beta_{5m} TFW_m + \sum_{n=0}^{2} \beta_{6n} ESW_n + \sum_{o=0}^{1} \beta_{7o} OW_o + \sum_{p=0}^{2} \beta_{8p}\, PO_p$$

where:

$\hat{P}$= Predicted Probability of Malnutrition, β_0 = Constant, RW_i = Women's Region at level i, PRW_j= Women's Place of Residence at level j, EDW_k= Educational Levels of Women at level k, SDW_l = Source of Drinking Water at level l, TFW_m=Toilet Facilities at level m, ESW_n = Economic Status of Women at level n, OW_o = Occupation of Women at level o, PO_p= Partner's Occupation at level p.

The value of explanatory variable for each category is taken as 1 if this variable falls in the corresponding category. For example,

RW_i = 1 for Women's Region of level = i and RW_i = 0 for other levels.

PRW_j = 1 Women's Place of Residence of level = j and PRW_j =0 for other levels.

Similarly, each of the other variables takes value 1 if it falls within the corresponding level of category. Based on the above result, the regression equation consisting of the significant variables is given by:

$$logit(\hat{P}) = -0.9514 + 0.2106RW_1 + 0.3031RW_2 + \cdots - 0.4846RW_{11} + 1.2558PRW_0 + 0.1607EDW_0 + 0.3553EDW_1 + 0.6670SDW_0 + 0.5200TFW_0 - 0.2604ESW_0 - 0.1352ESW_1 - 0.1319OW_0 - 0.3279PO_0 - 0.3161PO_1$$

The likelihood ratio test is used to test the goodness of fit of the model by comparing two nested models:- one with no variable called empty (intercept only) model and the other with all variables called saturated (full) model.

Table 4.3. Result of Model Fit Statistics for Empty and Full Model

Goodness of fit measure	Empty Model	Full Model
Log Likelihood	-4964.2077	-4444.4640
AIC	9930.415	8940.928
BIC	9937.437	9123.483

From Table 4.3, we can see that -2LL of the full model is -2(-4444.4640) =8888.9280 and -2LL of the empty model is -2(-4964.2077) =9928.4154 giving the difference of the deviances is (9928.4154-8888.9280) =1039.4874. Since log likelihood ratio test is Chi-square distributed with 25 degrees of freedom, $P(X^2(25) > 1039.4874) = 0.0000$, we can reject the null hypothesis of no significant difference between the two models. We use AIC and BIC values to determine the better model. Table 4.3. shows that the full model is better than the empty model because AIC and BIC are smaller than for the empty model.

The Hosmer-Lemeshow goodness of fit test was employed and the result is presented in table 4.4. below

Table 4.4: Test of Significance of Hosmer-Lemeshow Goodness of Fit Statistics

Hosmer-Lemeshow Goodness of Fit test		
Chi-Square	DF	Pr>Chi2
11.072	8	0.1976

The overall goodness of fit of the model was evaluated by Hosmer-Lemeshow goodness of fit test with the null hypothesis:

H_0: the model is a good fit

H1: the model is not a good fit

Since, the p-value as shown in the table 4.4 (0.1976) is greater than 0.05.We don't reject the null hypothesis and we conclude that the model is a good fit to the data.

To interpret the regression coefficient in logistic model we used odds ratio. The odds ratio indicate the effect of each explanatory variable directly on the odds of being malnourished rather than on log (odds). Estimates of odds greater than 1.0 indicate that the risk of malnutrition is greater than that for the reference category. Estimates less than 1.0 indicate that the risk of

malnutrition is less than that for the reference category of each variable. So, the final model presented in Table 4.2. is interpreted in terms of odds ratio as follows.

The risk of malnutrition for women residing in Tigray were found to be 23.4% (OR=1.234) times higher than those women in Dire Dawa controlling for other variables in the model. Malnourished women are 37.9% (OR=0.621) times lower when the women is residing in Amhara region compared to women in Dire Dawa controlling for other variables in the model.

Women who had no education were 17.44% more likely to be malnourished(OR=1.1744) compared to women with secondary or higher education controlling for other variables in the model, while women with primary education were 42.67% (OR=1.4267) more likely to be malnourished compared to women with secondary or higher education controlling for other variables in the model.

Women who live in rural area were 51.08% more likely to be malnourished (OR=3.5108) compared to women who live in urban area controlling for other variables in the model. Women who used non-improved source of drinking water were 94.85% more likely to be malnourished(OR=1.9485) compared to women who used improved source of drinking water controlling for other variables in the model. Women who had no toilet facilities were about 68.20% more likely to be malnourished (OR=1.682) than that of women who had toilet facilities controlling for other variables in the model.

The odds of women malnutrition lower by a factor of 0.7706 when the women was poor compared to rich women controlling for other variables in the model. While the odds of women malnutrition lower by a factor of 0.8735 when the women have medium economic status compared to rich women controlling for other variables in the model.

The odds of women malnutrition lower by a factor of 0.9677 when the women partners have no current work compared to women partners have non- agricultural work controlling for other variables in the model, while the odds of women malnutrition lower by a factor of 0.7289 when the women partners have agricultural work compared to women partners who have non-agricultural work controlling for other variables in the model. The odds of women malnutrition

lower by a factor of 0.8763 when the women have no current work compared to women who have current work controlling for other variables in the model.

Using the derived logistic regression model,

$$logit(\hat{P}) = -0.9514 + 0.2106RW_1 + 0.3031RW_2 + \cdots - 0.4846RW_{11} + 1.2558PRW_0 + 0.1607EDW_0 + 0.3553EDW_1 + 0.6670SDW_0 + 0.5200TFW_0 - 0.2604ESW_0 - 0.1352ESW_1 - 0.1319OW_0 - 0.3279PO_0 - 0.3161PO_1$$

It is possible to calculate the predicted value of the probability of malnutrition for any combination of values of the explanatory variables. For example, for unmarried women who had no work from Amhara region, aged 20, with primary education reside in rural areas, and living in poor households with an access of non-improved drinking water and no toilet facilities, the predicted probability of being malnourished is estimated to be about 21.5%.

4.2.1. Model Diagnostics

The adequacy of the fitted model was checked for possible presence and treatment of outliers and influential values. The diagnostic test results for detection of outliers and influential values are presented in Appendix A. The DFBETAs for model parameters including the constant term and Cook's influence statistic were both less than unity. DFBETAs less than unity imply no specific impact of an observation on the coefficient of a particular predictor variable, while Cook's distance less than unity showed that an observation had no overall impact on the estimated vector of regression coefficients β. 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, we can say that our model is adequate (see Appendix A and B).

4.3.Results of Multilevel Logistic Regression Analysis

The data used in this study have a hierarchical structure. Units at one level are nested within units at the next higher level. Here, the lower level (level-1) units are women, and the higher level (level-2) units are the regions that constitute the groups into which the women are clustered or nested. The nesting structure is women within regions that resulted in a set of 11 regions with a total of 8278 women.

In this section three multilevel logistic regression models (namely empty model with random intercept, random intercept with fixed effects model and random coefficient with random intercept model) have been considered and model comparison, testing goodness of fit and interpretation of fixed effects in terms of odds ratio are presented.

For the proper application of multilevel analysis first we have to test for heterogeneity of proportions between regions. The chi-square test was applied to assess heterogeneity among regions. The test yields X^2= 427.2811 with d.f 10 (P=0.000). Thus, there is evidence of heterogeneity among the regions with respect to malnutrition of women.

4.3.1. Random Intercept Only Model

First we fit an intercept-only model that predicts the probability of being malnourished. The functional form of the model is:

$$logit(P_j) = \beta_o + U_{oj}$$

where:-$U_{oj} \sim$ IID $(0,\sigma^2_u)$.

The estimates of parameters and standard errors are presented below in Table 4.5. The maximum likelihood estimate of the empty model of standard logit model is -0.9745 with z-value of -5.44 and p- value of 0.000. The intercept informs us $\widehat{\beta_o}$= -0.9745 that the average probability of malnutrition in Ethiopia is exp (-0.9745)/ [1+exp (- 0.9745)] =0.2739 which means the chance of women malnutrition is 27.39% on average.

Table 4.5: Result of Parameter Estimate of Random Intercept-Only Model

BMI Coef. Std. Err. z P>z	[95% Conf.Interval]
_cons -.9745449 .1790682 -5.44 0.000	-1.325512-.6235777
Random-effects Parameters Estimate Std. Err.	[95% Conf.Interval]
REG: Identity	
var(_cons) .3443335 .1525205	.1445255.8203781

LR test vs. logistic regression: chibar2(01) = 387.98 Prob>=chibar2 = 0.0000

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	8278	.	-4770.217	2	9544.435	9558.477

Note: N=Obs used in calculating BIC; see [R] BIC note

The table also contains the variance estimate of random effects at regional level, σ^2_u=0.3443 which implies that the between region variance of women malnutrition is 0.3443. In the

hypothesis H_0:σ^2_u=0 is provided that there is no cross-regional variation in women malnutrition. For this hypothesis, we observed that the value of the test statistic is 387.98 with p value (p = 0.0000). Therefore, the null hypothesis is rejected and there is evidence of cross-regional variation in women malnutrition. The empty model with random effect also helps to obtain the between region variations using intra -class correlation coefficient (ICC). ICC for this model is calculated by using formula (3.29) and this result ICC=0.0947 implied that 9.47% of the variation in malnutrition can be explained by grouping the women in regions (higher level units). The remaining (100-9.47%=90.53%) of the variation in malnutrition is explained within region-lower level units.

We can now write the model for the j[th] region as:- $logit(P_j) = -0.9745 + U_{oj}$. From the model we can say that the average probability of women malnutrition in the absence of covariates in region j is less than the average when U_{0j} is negative while it is higher than the average when U_{0j} is positive.

4.3.2. Random Intercept and Fixed Effect Model

We extended our model to allow for regional effects on the probability of being malnourished. We began with a random intercept model that allows the overall probability of malnutrition to vary across regions. The results of two-level random intercept and fixed slope model are presented in Table 4.6.

Table 4.6: Result of Parameter Estimate of Random Intercept and Fixed Slope Model

Variables	Coefficient	Odds ratio	Std .Err.	z	P>z	[95% Conf. Interval]
Age					**0.0544**	
15-24	-.1688834	.8446074	.0771474	-2.19	0.029*	-.3200896 -.0176772
25-34	-.1040809	.9011524	.0581201	-1.79	0.073	-.2179941 .0098323
35-49(Ref)						
Place of Residence					**0.000***	
Rural	1.263603	3.538145	.10304	12.26	0.000*	1.061648 1.465557
Urban(Ref)						
Education Level					**0.003***	
No Education	.1675489	.1861918	.157469	1.06	0.287	-.1410846 .4761824
Primary	.3630109	.2174162	.1512301	2.40	0.016*	.0666053 .6594164
Secondary+(Ref)						
Source of Drinking Water					**0.000***	

Non-Improved Source	.6640554	1.942655	.0626545	10.60	0.000*	.5412549 .7868559
Improved Source(Ref)						
Toilet Facilities					**0.000***	
No Facilities	.529655	1.698346	.0654536	8.09	0.000*	.4013682 .6579417
Have Facilities(Ref)						
Economic Status					**0.004***	
Poor	-.2558287	0 .7742746	.0775008	-3.30	0.001*	-.4077274 -.1039299
Medium	-.1350908	1 .8736366	.0871402	-1.55	0.121	-.3058824 .0357008
Rich(Ref)						
Marital Status					**0.438**	
Unmarried	-.0575131	.9441096	.0741228	-0.78	0.438	-.2027912 .087765
Married(Ref)						
Partner's Education Level					**0.2979**	
No Education						
Primary	.1764467	1.192971	.113525	1.55	0.120	-.0460582 .3989516
Secondary+(Ref)	.1344832	1.143945	.1073941	1.25	0.210	-.0760054 .3449717
Partner's Occupation					**0.000***	
Did not Work	-.0241697	0 .97612	.1928126	-0.13	0.900	-.4020755 .353736
Agricultural Work	-.3216887	1 .7249238	.0805	-4.00	0.000*	-.4794658 -.1639116
Non-Agricultural(Ref)						
Occupation					**0.024***	
Has no Work	-.1290516	.8789286	.0573248	-2.25	0.024*	-.2414062 -.016697
Has Work(Ref)						
_cons	-2.359627		.1790789	-13.18	0.000*	-2.710615 -2.008639

Random effects Parameters	Estimate	Std. Err.	[95% Conf. Interval]
REG: Identity var(_cons)	.1282727	.0581813	.0527291.3120455

LR test vs. logistic regression: chibar2(01) = 163.61 Prob>=chibar2 = 0.0000

Model	Obs	ll(null)	ll(model) df	AIC	BIC
.	8278	.-4465.486	17	8964.972	9084.335

*Significant (p<0.05), Ref=Reference Category

Table 4.7. Model selection criteria and likelihood ratio test

	Random Intercept Only Model	Random Intercept with Fixed Effects Model
Log likely hood(LL)	-4770.2174	-4465.4858

-2LL=Deviance	9540.4348	8930.9716
AIC	9544.435	8964.972
BIC	9558.477	9084.335

The table contains estimates of the fixed slopes and associated odds ratios. Values of the Wald test statistic used for testing for the significance of individual predictors are given in the table 4.7. The Wald test of overall goodness of fit gives Wald chi2 (15) =525.84 with p =0.000 where 15 is the degrees of freedom. This indicates that all explanatory variables jointly are significant. From the table we see that the inclusion of level one covariates decreased regional variations from 0.344 (level-two variance without covariates) to 0.128, it indicates that there is a significant variation between regions in women malnutrition.

The deviance of the random intercept model, 9540.4348 is reduced to 8930.9716 when we include covariates for the same random intercept which implies that the random intercept with fixed slope model is better than the random intercept only model. The AIC and BIC values in Table 4.8 ensure that the smaller the values of AIC and BIC the better the model is.

4.3.3. The Random Coefficient Model

In this model we are going to see the effect of women's level covariates by allowing them to vary randomly across regions. This model contains fixed effects and random effects. In this section we investigate whether level-one covariates have random effects across regions or they have the same effects across regions. Estimates of this model showed that the variance of random slopes of all included variables is zero except for education levels and economic status. This indicates that only the effects of education levels and economic status varied across regions whereas the effect of other covariates for women malnutrition remained fixed across regions. The results of the random slope estimates are given in Table 4.8 below.

Table 4.8: Result of Parameter Estimate of Random Coefficient Model

Variables	Coefficient	Std. Err.	z	P>z	Odds ratios	[95% Conf. Interval]
Age				**0.094**		
15-24	-.1473496	.0777299	-1.90	0.058	.857135	-.2996974 .0049982
24-35	-.1003797	.0584888	-1.72	0.086	.9031847	-.2150156 .0142562
35-49(Ref)						

Place of Residence				**0.000***			
Rural	1.254852	.104779	11.98	0.000*	3.566856	1.049489	1.460215
Urban(Ref)							
Education Level				**0.011***			
No Education	.1764542	.1684887	1.05	0.295	1.187542	-.1537775	.5066859
Primary	.3462303	.1559034	2.22	0.026*	1.417875	.0406653	.6517954
Secondary+ (Ref)							
Source of Drinking Water				**0.000***			
Non-Improved Source	.6925773	.0632565	10.95	0.000*	1.992837	.5685968	.8165577
Improved Source(Ref)							
Toilet Facilities				**0.000***			
No Facilities	.494237	.0662648	7.46	0.000*	1.63544	.3643603	.6241137
Have Facilities(Ref)							
Economic Status				**0.379**			
Poor	-.2290414	.1671391	-1.37	0.171	.7916245	-.5566281	.0985453
Medium	-.1371283	.1138278	-1.20	0.228	.8679583	-.3602267	.0859701
Rich(Ref)							
Marital Status				**0.389**			
Unmarried	-.0643282	.0746195	-0.86	0.389	.9370577	-.2105798	.0819235
Married(Ref)							
Partner's Education Level				**0.169**			
No Education	.2168466	.1153514	1.88	0.060	1.227365	-.0092381	.4429313
Primary	.1643992	.1090498	1.51	0.132	1.170142	-.0493345	.3781328
Secondary+(Ref)							
Partner's Occupation				**0.001***			
Did not Work	-.1211298	.1975727	-0.61	0.540	.8980616	-.5083651	.2661055
Agricultural	-.3127204	.0808977	-3.87	0.000*	.735507	-.4712771	-.1541638
Non-Agricultural(Ref)							
Occupation				**0.024***			
Has no Work	-.1301692	.0578557	-2.25	0.024*	.8770667	-.2435643	-.016774
Has Work(Ref)							
_cons	-2.392186	.1766106	-13.54	0.000*		-2.738336	-2.046036

*Significant ($p<0.05$), Ref=Reference Category

Random-effects Parameters	Estimate	Std. Err.	[95% Conf.Interval]

REG: Unstructured				
var(EDL)	.0074195	.0151725	.0001348	.4083524
var(ECOS)	.0522985	.0280879	.018253	.1498455
var(_cons)	.2551704	.1220952	.0998949	.6518045
cov(EDL,ECOS)	.001247	.0144785	-.0271302	.0296243
cov(EDL,_cons)	-.0039888	.0288917	-.0606155	.0526378
cov(ECOS,_cons)	-.0953066	.0523784	-.1979664	.0073532

LR test vs. logistic regression: chi2(6) = 204.63 Prob> chi2 = 0.0000

In Table 4.8, the value of Var (EDL) and Var (ECOS) are the estimated variance of education level and economic status respectively. These estimated variances indicated that there is a significant variation in the effect of education level and economic status across regions in Ethiopia.

The estimate of the fixed intercept is -2.392 and the log-odds of the probability of women malnutrition when all level one covariates are zero in region j is given by -2.392+ûj Where ûj is a random intercept with variance of 0.255 which is the between-regions variance and standard error 0.122.The individual region slopes of education level (EDL) and economic status (ECOS) vary with variance 0.0074 and 0.0522 respectively.

Generally, interpretation of significant covariance terms can be easily made in terms of the correlation coefficients between random intercept and random slopes. Positive correlation between intercept and slopes implies that regions with higher intercepts tend to have on average higher slopes. The negative sign for the correlation between intercepts and slopes implies that regions with higher intercepts tend to have on average lower slopes on the corresponding predictors.

Table 4.9 Random-Effects Correlation Matrix for Level Region

	EDL	**ECOS**	**Cons**
EDL	1		
ECOS	0.0633	1	
Cons	-0.0916	-0.8251	1

The value of AIC and BIC can be used to make an overall comparison of this model with the random intercept with fixed slope model. We observed from table 4.10 that the value of fit

statistics for random coefficient model is less than random intercept model. This indicates that the random coefficient model is a better fit as compared to the random intercept and fixed effect model.

Table 4.10 Results of model selection criteria and log likelihood ratio test

	Random Intercept and Fixed Slope Model	**Random Coefficient Model**
Log Likelihood	-4465.4858	-4449.769
Deviance	8930.9716	8899.538
AIC	8964.972	8937.537
BIC	9084.335	9070.943

The parameters of observed variables can be interpreted much the same way as those from the standard logit model. Thus, everything else being equal except slight difference on random effect in the model, women who used non-improved water source were 99.28% (OR=1.9928) and have no toilet facilities were 63.54% (1.6354) more likely to be malnourished compared to women who used improved water source and have toilet facilities respectively controlling for other variables in the model and random effect at level two. Similarly, women who lives in rural area 3.566 (OR=3.566) times more likely malnourished than women who lives in urban area controlling for other variables in the model and random effect at level two.

Women who has no work were 12.3% (OR=0.877) less likely malnourished compared to women who has work controlling for other variables in the model and random effects at level two. Similarly, women partners who have no work were 10.2% (OR=0.898) less likely malnourished compared to women partners who have non-agricultural work controlling for other variables in the model and random effects at level two, while women partners who have agricultural work were 26.45% (OR=0.7355) less likely malnourished compared to women partners who have non-agricultural work controlling for other variables in the model and random effects at level two.

4.3.4. Goodness of Fit Test

An overall evaluation of the multilevel logistic model was assessed using the deviance. The test is done by comparing the deviance of two models by subtracting the smaller deviance from the larger deviance. The difference is a chi-square test with the number of degrees of freedom equal to the number of different parameters in the two models. The significance of this chi square test indicates that the model is a good fit. Similarly, it was also assessed by using AIC and BIC. Based on Table 4.10 random coefficient model have a significant deviance chi-square and the value of AIC and BIC is less than the model we obtained in the random intercept with fixed slope model. So, we conclude that the model is a good fit.

4.3.5. Diagnostic Checking

The diagnostic test results for detection of outliers and influential values are presented in Appendix C. Based on the results the value of leverage and influential observation is less than one. Thus, from the goodness of fit test and diagnostic test results, we can say that the fitted model is adequate.

5. DISCUSSION, CONCLUSTION AND RECOMMENDATIONS

5.1. Discussion

This study found that some of the variables considered have significant influence on women malnutrition. Place of residence, region, education levels, source of drinking water, toilet facilities, economic status, women occupation and women partner's occupation were found to be important determinants of women malnutrition among reproductive age (15-49 years). Based on the findings of previous results, this study made a few comparative discussion as follows.

Women who had no education were more likely to be malnourished (OR=1.174) compared to women with secondary or higher education controlling for other variables in the model. Women with primary education were more likely (OR=1.426) to be malnourished compared to women with secondary or higher education. This finding is consistent with other studies (Behrman and Rosenzweig 2002; Plug 2004; Benson 2004; Grossman 2006). The reason might be that women who receive even minimal education are generally more aware than those who have no education of how to utilize available resources for the improvement of their own nutritional status and that of their families and low level of educational background could be associated with women's lack of decision-making power, which in turn has played a role in increasing malnutrition rate.

Similarly, place of residence is a significant factor contributing to being malnourished. The results of this study also show that there is a difference in women malnutrition who reside in rural and urban areas. Women who reside in rural areas are more likely to be malnourished than women who reside in urban areas. Similar results have been reported from earlier studies in Ethiopia and elsewhere in sub-Saharan Africa and in India (Uthman and Aremo, 2008; Ramesh, 2004; Teller and Yimer, 2000).This may be due to fact that women residing in rural areas have low access of health care, safe water, sanitation facilities and unequal distribution of infrastructures. Another important reason associated with low nutritional status of rural women may be the higher levels of labor or workload among rural women compared with their urban counterparts.

Regarding the regional variations in malnutrition, results for the total sample of women confirmed that women who live in Tigray, Afar, Somali and Gambella are at a higher risk of

malnutrition than those in Dire Dawa region. All of the regions having a relatively higher prevalence of malnutrition are found in the lowlands of the country, with the exception of the highlands of Tigray. This is in agreement with the findings in other studies (Jemal et al., 2003; Woldemariam and Timotiwos, 2002). The probable reason for this could be associated with tropical diseases like malaria and sleeping sickness are relatively more common in the lowlands of Ethiopia, which are immediate factors that reduce the nutritional status of women. Moreover, the educational level of women in the lowlands was significantly low that of women in the highlands. In contrast the low BMI value in women living in the highlands of Tigray may be related to low agricultural productivity because of shortage of arable land and livestock products.

Source of drinking water and toilet facilities are the most important determinants of women malnutrition in Ethiopia. According to our findings, women who used non-improved water source and have no toilet facilities as compared to women who used improved source and have toilet facilities, the risk of being malnourished were highly significant. This finding is consistent with that in Haseen, (2003) showing that women who used non-improved water source and have no toilet facilities have higher rates of malnutrition. The probable explanation for this could be that women who have no access of safe water and toilet facilities leads to exposure to repeated enteric infections (with diarrhea, intestinal parasites) or malaria. Where such infections are not lethal, evidence suggests that exposure to water related diseases, particularly helminthes, still leads to irreversible growth faltering, lowered immunity and increased morbidity. Enteric infections increase risk and severity of malnutrition via a number of different mechanisms (UNICEF cited in Smith et al., 2005).

Occupation was found to be one of the determinant predictors of risk of malnutrition. Unemployed women are less likely, malnourished than employed women. The same result has been observed by Bamji and Thimayamma, (2000). The probable reason for this could be that women who have work may lack the time to adequately prepare nutritious meals for herself, or to make use of public services designed to improve their nutrition. It has been noted that the dual role of women as mothers and productive workers is compromised by poor diets and ill health; not only their own well-being but that of the whole family is affected. A heavy work load may push a woman with marginal food intake over the brink and into a state of malnutrition. Unemployed women's have enough time to prepare healthy food and prevent herself from

nutritional related diseases. Another important determinant of the nutritional status of women in Ethiopia is economic status and partner's occupation. In this thesis unexpected results observed in the economic status and partner's occupation due to missing observation in the data.

There are no studies involving multilevel modeling of women malnutrition in Ethiopia that included variables at higher levels. The present study also identified indicators of the region as predictors of malnutrition. These are education levels and economic status in different regions of Ethiopia. According to the final model, these level-two variables explain regional-level variation in malnutrition based on the data.

5.2. Conclusion and Recommendations

In Ethiopia rural women were more likely to be affected by malnutrition than their urban counterparts. Uneducated women were more likely to be malnourished than educated women. Women who use drinking water from unprotected sources and have no toilet facilities were more likely malnourished. Women who have work were more likely malnourished than without work. Among regions, women living in Tigray, Affar, Somali and Gambella were more likely to be malnourished.

Secondly, from among the ten explanatory variables considered the effect of the random part of education level and economic status on women malnutrition differs across regions. In general, the results of the study manifest regional differences in the women malnutrition and its determinants. This may be associated with limited healthcare facilities, dietary practices, inequality in the distribution of service and resources.

Based on our findings, we recommend the following:-

- The government should give more support to those regions with high rates of malnutrition.
- Government and non-government organizations should focus on educating women as these are effective means of advancing good nutritional status and decreasing the rate of women malnutrition.

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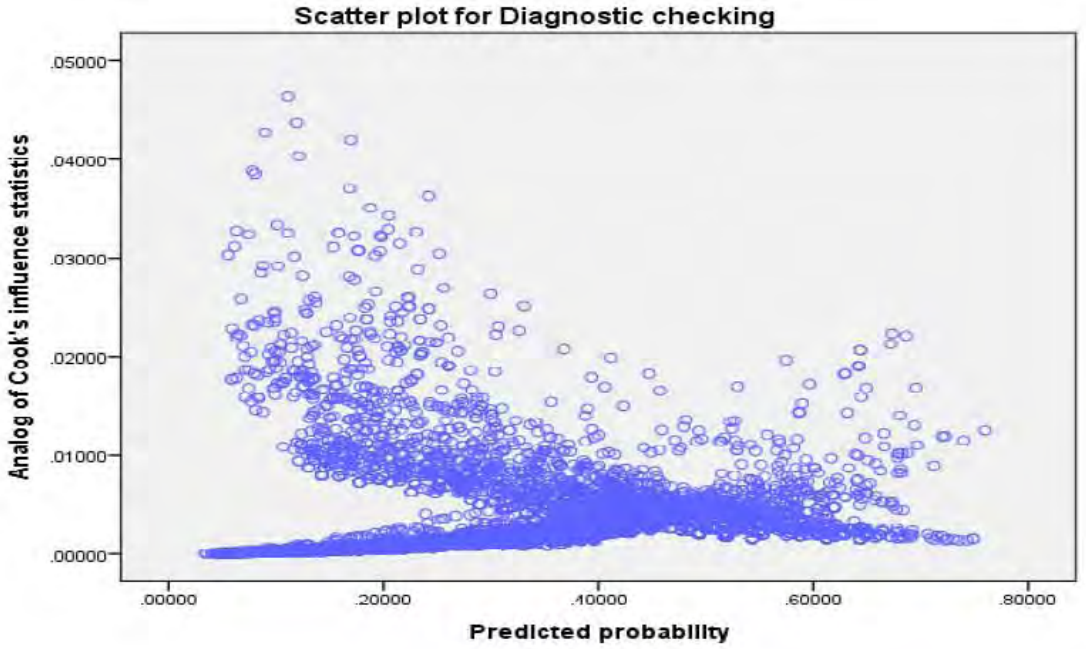
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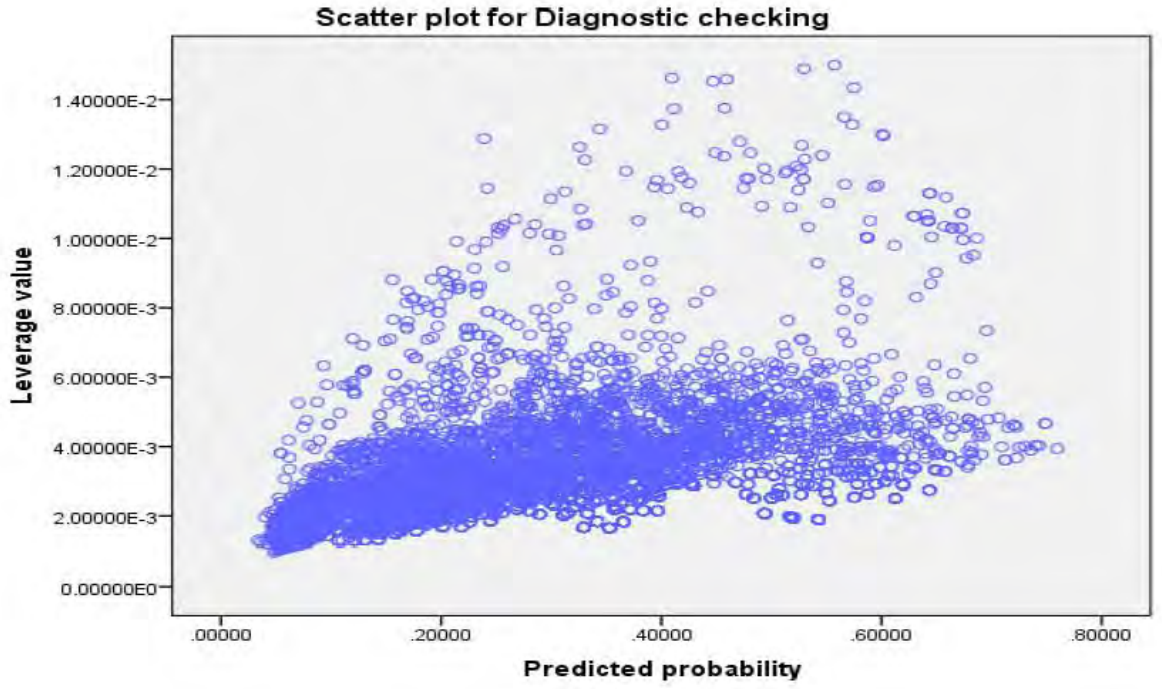
7. APPENDIXES

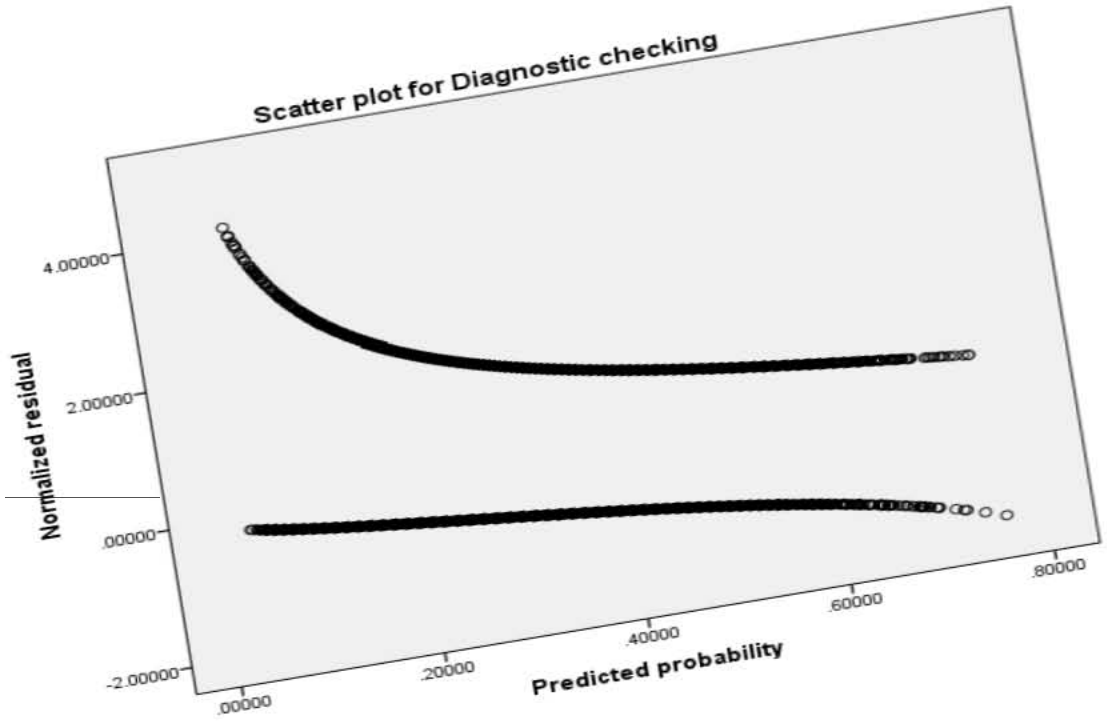
Appendix A: Result of Diagnostic Tests for Outliers and Influential Value for Standard logistic regression

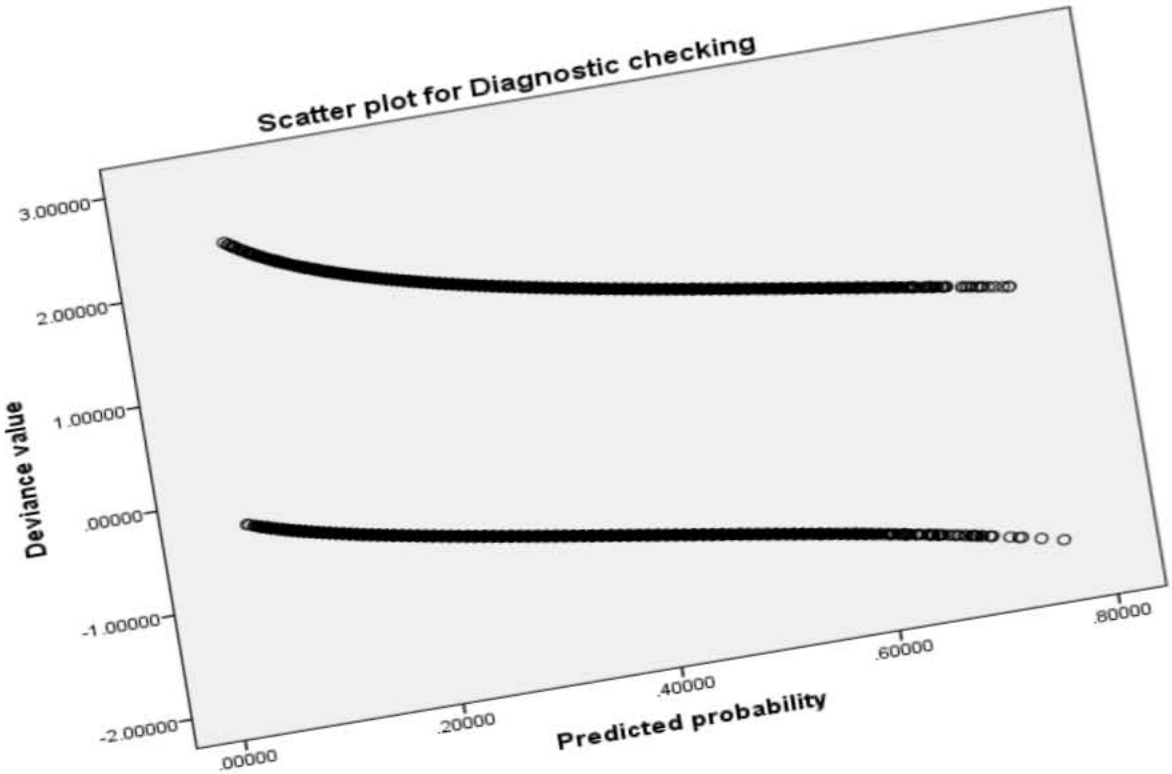
Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Analog of cook's	8278	.00005	.04639	0.0032018	0.00464200
Leverage value	8278	.00099	.01499	.0031409	.00154726
DFBETA for constant	8278	-.01126	.02059	2E-7	.00174434
DFBETA for AGE(1)	8278	-.00291	.00535	0E-7	.00086013
DFBETA for AGE(2)	8278	-.00186	.00242	0E-7	.00063791
DFBETA for REG(1)	8278	-.01128	.00743	-1E-7	.00146166
DFBETA for REG(2)	8278	-.01115	.00833	-1E-7	.00154839
DFBETA for REG(3)	8278	-.01151	.00800	-1E-7	.00149018
DFBETA for REG(4)	8278	-.01078	.00777	-1E-7	.00147126
DFBETA for REG(5)	8278	-.01135	.01169	-1E-7	.00167884
DFBETA for REG(6)	8278	-.01146	.00962	-1E-7	.00159983
DFBETA for REG(7)	8278	-.01150	.00893	-1E-7	.00155600
DFBETA for REG(8)	8278	-.01145	.00829	-1E-7	.00153088
DFBETA for REG(9)	8278	-.01098	.01270	0E-7	.00170629
DFBETA for REG(10)	8278	-.01407	.02215	3E-7	.00201842
DFBETA for PRS(1)	8278	-.01002	.00903	1E-7	.00136894
DFBETA for EDL(1)	8278	-.01925	.01525	-2E-7	.00178605
DFBETA for EDL(2)	8278	-.01905	.01323	-2E-7	.00168273
DFBETA for SDW(1)	8278	-.00271	.00321	0E-7	.00067672
DFBETA for SAN(1)	8278	-.00305	.00427	0E-7	.00073614
DFBETA for ECOS(1)	8278	-.00369	.00418	0E-7	.00087787
DFBETA for ECOS(2)	8278	-.00309	.00638	0E-7	.00098183
DFBETA for MAR(1)	8278	-.00328	.00448	0E-7	.00081713
DFBETA for PEDL(1)	8278	-.01031	.00894	0E-7	.00128404
DFBETA for PEDL(2)	8278	-.00947	.00829	0E-7	.00121302
DFBETA for PEMPS(1)	8278	-.02170	.03224	0E-7	.00215474
DFBETA for PEMPS(2)	8278	-.00510	.00654	-1E-7	.00092166
DFBETA for EMPS(1)	8278	-.00206	.00219	0E-7	.00063874
Valid N (listwise)	8278				

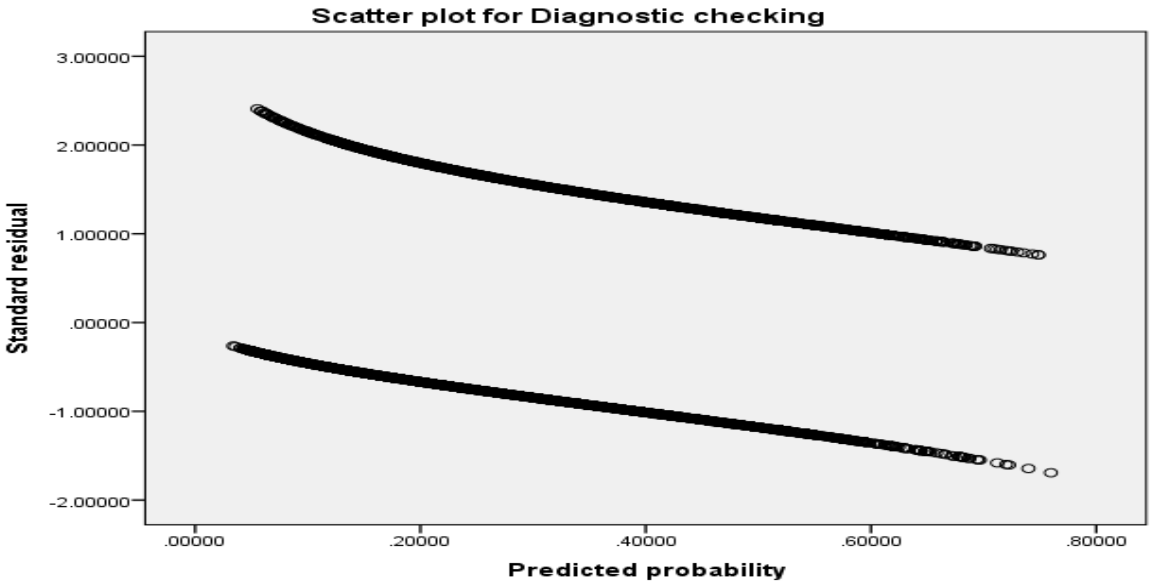
APPENDIX B: Scatter Plots for Diagnostic Checking for Standard Logistic Model





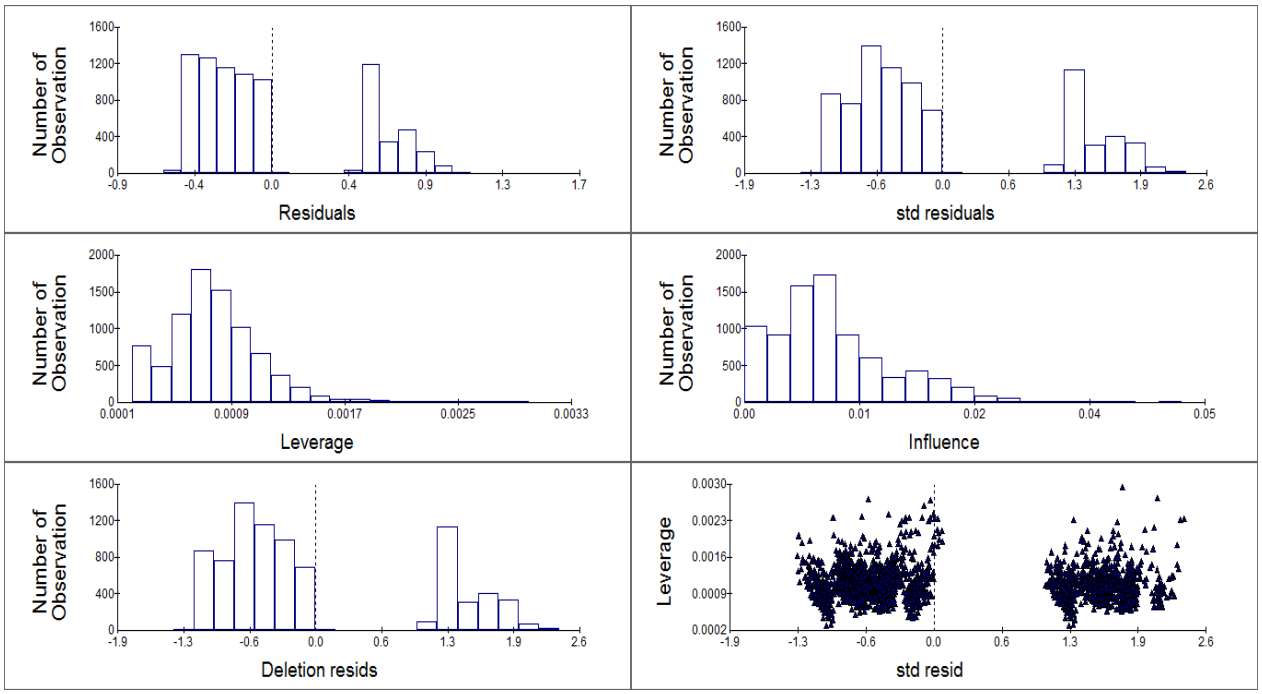

Scatter plot for Diagnostic checking
Normalized residual
4.00000
2.00000
.00000
-2.00000
.00000
.20000
.40000
.60000
.80000
Predicted probability


Scatter plot for Diagnostic checking
Deviance value
3.00000
2.00000
1.00000
.00000
-1.00000
-2.00000
.00000
.20000
.40000
.60000
.80000
Predicted probability

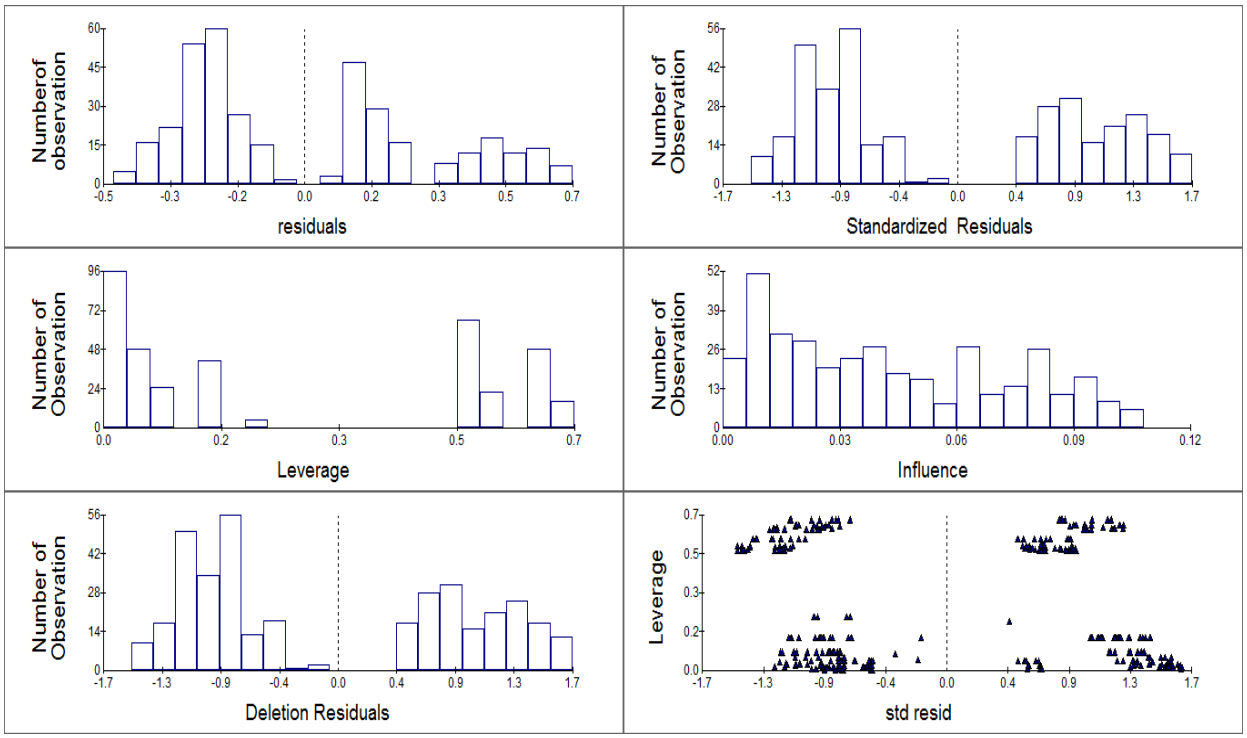


Appendix C: Diagnostic Checking for the Multilevel Model

1. Residual Plots for Level-One



2. Residual Plots for Level-Two



DECLARATION

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

Name: _____

Signature: _____

Date: _____

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

M.K.Sharma