Nutrition, Childhood Development and Prevalence of Anemia in Ghanaian Children: Analysis of Health Survey

NUTRITION, CHILDHOOD DEVELOPMENT AND PREVALENCE OF ANEMIA IN GHANAIAN CHILDREN: ANALYSIS OF HEALTH SURVEY

BY

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A Thesis
Submitted to the Department of Mathematics & Statistics
and the School of Graduate Studies
of McMaster University
in Partial Fulfilment of the Requirements
for the Degree of
Master of Science

Master of Science (2013)	McMaster University
(Mathematics & Statistics)	Hamilton, Ontario, Canada

TITLE:	Nutrition, Childhood Development and Prevalence of Anemia in Ghanaian Children: Analysis of Health Survey
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NUMBER OF PAGES:	x, 102

To my loving mother Dorcas Ama Blankson and brother Nana Kojo Blankson

Abstract

Malnutrition and Anemia in children continue to be major public health challenges in most developing countries, particularly in Africa. Malnutrition and Anemia pervade all aspects of their health, growth, cognitive and social development. They lead to irreversible and lifelong effects that prevent children from realising their full potential. This study was designed to examine the prevalence and determinants of malnutrition and anemia in children under 5 years of age in the Ghanaian population.

This research is based on data from the Ghana Demographic and Health Survey (GDHS) 2008, obtained from the Ghana Statistical Service (GSS). The survey is an extensive survey conducted using a stratified, two-stage cluster sampling design. The GDHS data contains a wealth of information on health, demographic, as well as socio-economic factors but is underutilised due to the complexity of the survey data. This study therefore stands out as one of the few that use the GDHS to investigate aspects of child health in Ghana.

In this study, we perform subgroup analysis by disaggregating the data by age and gender specific subgroups and then by place of residence and region. This was in order to identify sub level estimates as national estimates have a high tendency of concealing true values and deviations from general trends. Also, subgroup analysis is very significant especially for resource allocation so as to minimize the likelihood of

missing the target populations.

We investigated associations between the three measurements of malnutrition; stunting, underweight and wasting and anemia (assessed by haemoglobin concentration) and the various risk factors using chi-square test to examine bivariate associations and chi-square trend test to examine linear trends in association.

We identified the following variables to be significantly associated with all forms of malnutrition and/or anemia: age of child, mother's education, financial status and place of residence. Other factors that were identified to be associated with some form of malnutrition and/or anemia include duration of breastfeeding, source of drinking water, mother's occupation and currently breastfeeding.

In view of the high rate of malnutrition, approximately 36% $(33.6 - 37.6)$ and the alarming prevalence of anemia, 78% $(76.7 - 80.2)$ in children in Ghana, particularly among those less than 2 years old, and the grave consequences on their cognitive and behavioral development even in later years, there is an urgent need for effective and efficient public health interventions.

Acknowledgements

I would like to thank the Almighty God for His guidance and help throughout my study at McMaster University and stay in Canada. I would like to express my sincere gratitude to my supervisor Dr. Jemila Hamid for not only introducing me to the field of Clinical Epidemiology and Biostatistics but also for her excellent supervision, patience, wealth of knowledge and incessant encouragement. I could not be more grateful for her cooperation and enthusiasm that contributed greatly to this thesis. I would like to thank my supervisory committee members Dr. Roman Viveros-Aguilera and Dr. Joseph Beyene for their input and suggestions.

I also extend my warmest gratitude to the faculty and staff of the Department of Mathematics and Statistics for providing a motivating and friendly learning environment. I am appreciative of all those who have helped to make my stay in Canada wonderful especially the Keowns, Odames, Bowens and the Masons. I also thank my friends Priscilla Gambrah, Caitlin Daly, Oscar Kuffour and Taddele Kibret for being with me throughout both the good and the challenging times.

My immense gratitude goes to my mum for her prayers, encouragement and for believing in me even during the moments when I thought it was impossible. Finally, I would like to say a big thank you to my family and friends for their support, kind words and encouragement throughout the entire period.

Contents

List of Figures

Chapter 1

INTRODUCTION

Research involving childhood growth and development has become increasingly important as several international agencies, governments and civil societies agree that investing in the health of the young child today will lead to an improved society in the future. The relevance of childhood growth and development cannot be underestimated for a lot of reasons (Nikoi, 2011).

One reason why adequate child health is important is that it leads to successful adult life. Children who lack basic health care needs are more susceptible to infections and diseases and more prone to delayed mental and cognitive development. This leads to poor school performance when they are enrolled in school leading to a reduction in intellectual achievement and subsequently reduced work capacity and undermined earnings in their adulthood. In effect, economic productivity is decreased (Wagstaff *et al.*, 2004; Villalpando *et al.*, 2003).

Another reason for child health investment is that it is economically prudent. The World Bank reports that Vitamin A supplementation and immunisation are the most cost-effective interventions that can be implemented to ensure the well-being of the child. These interventions increase the ability of children to resist diseases and infections such as polio, measles, diphtheria, whooping cough and tuberculosis, thus decreasing the rate of infant and young child mortality especially from preventable infections. According to the United Nations report 2013, malnutrition problems cost the global economy 3.5 trillion dollars per year (Dadhich and Faridi, 2013). Over the next fifteen years, it's estimated that malnutrition will put nearly five hundred million young children at risk of permanent health problems (Dadhich and Faridi, 2013). However this threat could be averted with timely investment in child health which will help save the cost of later treatment for nutrient deficiency.

Yet another reason for investing in child health can be linked to balanced population dynamics and control. When children have adequate health care, parents are convinced of their survival hence they are more likely to have fewer children and will be able to take proper care of them, also the government will be able to invest more in the health and total well being of each child (Nikoi, 2011).

The United Nations Convention on the Rights of the Child holds governments responsible to ensure children's right to the highest attainable standard of health by providing breastfeeding support, adequate nutritious foods, appropriate health care and clean drinking water (Wuehler *et al.*, 2011). The International Convention on Economic, Social and Cultural Rights also states that everyone has the right to adequate food and the highest attainable standards of health (Wuehler *et al.*, 2011). These policies have created an outline for child-centered policies worldwide and resulted in an impulsion of research into the well-being of children. In spite of all the welcomed efforts and commitments to ensuring advancements in childhood growth and development, in practice there is still a shortfall in meeting the set goals and targets (Wuehler *et al.*, 2011). The improvement and expansion of the efforts by all the stakeholders interested with the growth and development of children is therefore a high need.

Ensuring adequate well-being of a child involves securing a child's safety, happiness and health. It also involves giving them the opportunity to develop positive and adequate interpersonal relationships (African Child Policy Forum, 2008). The World Health Organization (WHO) Commission on social determinants of health has called for national and global health equity surveillance systems for monitoring of policy and action to reduce health inequity and to create a more just and fair society (Lakshman *et al.*, 2013). Promoting the right to adequate food and applying human right approaches to nutrition contribute to tackling immediate underlying and root causes of malnutrition (Wuehler *et al.*, 2011). The current study involves an analysis of the various factors that contribute to the nutritional status and general well-being of children under the age of 5 in Ghana.

1.1 Concept of Malnutrition and Micro-nutrient Deficiency

Child nutrition refers to dietary needs of children and involves ensuring that children eat the right foods and in the right proportions to help them grow normally, as well as prevent stunting, wasting, obesity and the incidence of diseases. Good nutrition refers not only to the quantity but also the quality of food consumed to ensure adequate physical, mental and social well-being. The United Nations Development Program (UNDP) in its 1990 human development report defined a Human Development Index which attempts to measure the well-being of nations. These indices which meaningfully monitor the differences in human development over time and space include health, education, income and poverty. Over the years, other researchers have expanded the indices to include empowerment and physical safety, political and civil freedom and gender equality (Alkire, 2002; McGillivray, 2007).

The United Nations World Summit for Children Goals recognised child growth as an important public health indicator for monitoring nutritional status and health in populations (UNICEF *et al.*, 1993). Children who suffer from growth retardation due to poor feeding practices and/or recurrent infections tend to have more frequent episodes of severe diarrhea and are more susceptible to several infectious diseases such as malaria and pneumonia (De Onis and Blössner, 2003). Despite various policies have been implemented to ensure that optimum nutrition and consequently health is achieved especially in young children, maternal and child malnutrition however, continue to be global problems with important consequences for survival, incidence of acute and chronic diseases, healthy development and the economic productivity of individuals and societies (Black *et al.*, 2013).

Malnutrition is defined as a state in which the physical function of an individual is impaired to the point where he or she can no longer maintain natural bodily capacities such as growth, pregnancy, lactation, learning abilities, physical work as well as resisting and recovering from diseases (World Food Program, 2008). Malnutrition refers to both under-nutrition and over-nutrition (obesity/overweight). For the purposes of this study, malnutrition refers only to the problem of under nutrition as the prevalence of overweight in the Ghanaian children is not a public health problem.

Malnutrition and infection is the leading cause of death in children in developing countries with malnutrition estimated to account for more than half of childhood mortality annually (Neumann *et al.*, 2004). Malnutrition ranges from chronic and moderate to mild and silent forms. Protein Energy Malnutrition (PEM) is a form of malnutrition measured by the physical measurements of body (height and weight) and age (World Food Program, 2008).

Chronic malnutrition (stunting) refers to low height-for-age and is the effect of inadequate food intake over a long period of time. It is also defined as linear growth retardation (World Food Program, 2008). Acute malnutrition (wasting) refers to low weight-for-height and the result of inadequate food intake over a short period of time. It could also be due to a recent incidence of an infection or disease (World Food Program, 2008). Another form of malnutrition is reflected as being underweight that is low weight-for-age or being too thin for their age. Underweight is usually a manifestation of being either stunted or wasted or both (World Food Program, 2008). Micro-nutrient (vitamins and minerals) and macro-nutrient (protein, fat and carbohydrate) deficiencies in young children, often due to poor diet are also forms of malnutrition usually leading to severe health implications and devastating impact on their development (World Food Program, 2008). One incidence of micro-nutrient deficiency is Anemia.

According to the World Health Organisation, anemia is defined as a hemoglobin level of less than 5th percentile for age and has several causes which vary by age (Janus and Moerschel, 2010). Anemia in children under 5 years of age in particular is of much relevance because it impairs their mental and physical development (Villalpando *et al.*, 2003). It causes negative behavioural and cognitive effects resulting in poor school performance and reduced work capacity in later years. It also negatively affects their future social performance (Villalpando *et al.*, 2003). Iron deficiency is the most common cause of anemia in children under five (5) with a smaller proportion due to other micronutrient deficiency such as folate, Vitamin A and B12 (Villalpando *et al.*, 2003; Cornet *et al.*, 1998; Fleming and Werblińska, 1982). Other studies in developing countries have shown that iron deficiency anemia during the first two years of life leads to impairments in the mental, cognitive and behavioural developments that persist even after treatment of iron deficiency (Irwin and Kirchner, 2001; Lozoff *et al.*, 1991).

1.1.1 Global Prevalence of Malnutrition and Anemia in Children

In 2012, 6.6 million children under age 5 died, which translates to approximately 18000 deaths per day (You *et al.*, 2012). Most of these deaths occurred in the low income countries and specifically in the African Region where children are 16 times more likely to die than children in the developed countries (You *et al.*, 2012). More than half of these deaths are due to preventable infections and lack of access to simple, affordable interventions. The underlying cause of under-five deaths is malnutrition (You *et al.*, 2012).

The first Millennium Development Goals set up by the United Nations is to halve the proportion of extremely poor people by 2015 from the 1990 estimates. Closely linked to this goal is the reduction in the prevalence of underweight in children under the age of 5. The comparative quantification of health risk reports that the deaths of 3.7 million children under age 5 are associated with underweight of either the child or the mother of the child (Ezzati *et al.*, 2004).

Globally, a total of 162 million children under the age of 5 were stunted in 2012, a decrease from the 197 million reported in 2000 (UNICEF *et al.*, 2012). Also 99 million children under age 5 were underweight whiles 51 million were wasted with 17 million of them being severely wasted (UNICEF *et al.*, 2012). The lowest prevalence of wasting was reported in Latin America & the Caribbean, 1.4%. Children in South Asia are at the highest risk of being wasted having a wasting prevalence of 16.0%, which is twice the global prevalence (UNICEF *et al.*, 2012). The prevalence of wasting is an 11% decrease from the 1990 estimated figure of 58 million wasted children. The prevalence of underweight is a decrease from 25% in 1990 to 15% in 2012 (UNICEF *et al.*, 2012). This decreasing trend is rather at a slow pace and thus remains insufficient to meet the Millennium Development Goal of halving prevalence by 2015 (UNICEF *et al.*, 2013). The highest reduction in the prevalence of stunting was recorded in Asia and Latin America and the Caribbean, 40% reduction (UNICEF *et al.*, 2012). In Africa and Oceania, reduction has been rather modest, between 10% and 15% (UNICEF *et al.*, 2012). Similarly, the highest reduction in underweight prevalence was recorded in Latin America and the Caribbean, 56% reduction and the lowest was recorded in Africa having a 22% reduction in the prevalence of underweight (UNICEF *et al.*, 2012).

Some factors responsible for the slow pace in the decline of the prevalence of malnutrition especially among the African Region include extreme violence, social disruptions and natural disasters (UNICEF *et al.*, 2013).

The global prevalence of anemia in children under age 5 is 47.4%, that is about 293 million children are anemic (Benoist *et al.*, 2008). The highest overall prevalence is in Africa, 67.6% and South-East Asia 65.5%. In the Eastern Mediterranean, the prevalence is 46% and around 20% in the other WHO regions, the Americas, Europe and Western Pacific (Benoist *et al.*, 2008). In a study of iron deficiency anemia among Canadian children, Christofides *et al.* (2005) estimated the prevalence to range between 3.5% – 10.5%. In the United States, the prevalence is approximately 3.6% (Cusick *et al.*, 2008). In Europe, the prevalence of anemia in countries such as Sweden and Germany are 8.6% and 7.8% respectively (Benoist *et al.*, 2008).

1.1.2 Prevalence of Malnutrition and Anemia in African Children

The prevalence of stunting, underweight and wasting in Sub-Saharan Africa is 38.0%, 20.8% and 9.0% respectively (UNICEF *et al.*, 2012). The prevalence of stunting is slightly higher in Eastern and Southern Africa, 38.8% than in Western and Central Africa, 36.9% whiles the prevalence of underweight is higher in the Western and Central African Regions, 22.4% than in Eastern and Southern Africa, 18.3% (UNICEF *et al.*, 2012). Wasting prevalence is higher among children in Western and Central Africa, 10.6% than in children in the Eastern and Southern African area, 7.3% (UNICEF *et al.*, 2012). In some countries such as Sierra Leone, Niger and Central African Republic, the prevalence of underweight either worsened or did not improve over the period from 1990 to 2006 (World Food Program and UNICEF, 2006).

In almost all countries in the Sub-Saharan African region, the prevalence of anemia in children under age 5 is above the severe prevalence threshold of 40%. The highest overall prevalence of anemia in children under 5 years is recorded in the Western and Central African Region, 75% (Benoist *et al.*, 2008). While the prevalence of anemia in most African countries were high ranging from 74% in Tanzania to 43% in Democratic Republic of Congo (Premji *et al.*, 1995; Hedberg *et al.*, 1993), the prevalence of anemia among children under age 5 in countries such as Monaco and

Australia were as low as 5.0% and 1.1% respectively (Benoist *et al.*, 2008; Karr *et al.*, 1996).

Inadequate health care services and lack of access to effective health facilities and food resources are some underlying factors for the high levels of malnutrition and anemia in children in the Sub-Saharan African region (UNICEF., 2007). Other identified factors include struggling economies, high fertility rates which leads to overcrowding and subsequently reduction in the availability of food resources. Hence, there is an increased risk of malnutrition and micro-nutrient deficiency especially in vulnerable children (UNICEF., 2007).

With the current estimates and trends in malnutrition, only a few countries in Sub-Saharan Africa are capable of meeting the Millennium Development Goal (MDG) of halving extreme poverty and hunger by 2015 (African Child Policy Forum, 2008). The countries include Botswana, Guinea Bissau, Malawi, Congo, Mauritania and Ghana. These countries have adopted a widespread of basic interventions such as vitamin A supplementation, exclusive breastfeeding, and the use of insecticide treated bed nets to prevent malaria and immunization. They also have increased allocation of time and resources to health and education (African Child Policy Forum, 2008).

Ghana is one of the few countries in the Sub-Saharan African Region, specifically in West Africa that have a potential of meeting the first MDG target. This is as a result of the programs and interventions that have been introduced since the inception of the United Nations Convention on the Rights of the Child. The interventions include reforming the laws regarding children, initiating free compulsory universal basic education, creating a Ministry of Women and Children affairs and the onset of School Feeding Programme (Nikoi, 2011; Osei *et al.*, 2009).

These programs and reforms have led to an increase in school enrolment, immunization rates and general well-being of the children. The child mortality rate decreased from the 2003 estimate of 111 per 1000 births to 80 per 1000 births in 2008 (GSS and Macro, 2009). There was also a decrease in the overall prevalence of stunting and underweight from 35% to 28% and 18% to 14% respectively (GSS and Macro, 2009). The prevalence of anemia and wasting however increased slightly from the 2003 estimate of 76% to 78% and 8% to 9% respectively in 2008 (GSS and Macro, 2009). Generally, it is imperative to acknowledge that the country is making significant progress in child health and development. However there is substantially more room for improvement especially since the estimates are relatively still high as compared to the worldwide severity thresholds.

1.2 Rationale and Objectives of the Study

National and Regional estimates of the prevalence of malnutrition and anemia are available. Thus policy makers and program planning committee members and other non-governmental organisations are well informed of the regions with the greatest needs. What is widely unknown is the specific socio-demographic subgroups and subregional areas with specific needs. Due to this lack of information, directing the limited resources to the appropriate target areas is mostly a challenge and a contributing factor to missing the target population. Furthermore, identifying the specific variables associated with childhood nutrition and development is relevant in prioritising interventions and revealing patterns for improved results.

This study will perform an extensive analysis of the nutritional status of children under age 5 in Ghana using the Ghana Demographic and Health Survey. The association between their nutritional status and the various demographic and socio-economic status will also be investigated. The main questions that will be answered by this study are:

1. What is the prevalence of malnutrition and anemia among age as well as gender specific subgroups and socio-economic subgroups?
2. Does the place or region of residence of the child have contributing explanations to the differences in malnutrition and anemia prevalence?
3. Which child or maternal factors are associated with the differences in nutritional status and anemia prevalence?
4. How can policy makers and service providers use the findings of the study to improve child health in the country?

Children in the African region have a higher chance of being exposed to infectious diseases, poverty and detrimental economics due to multiple scales. Although this study is based on research done in Ghana, the results are expected to contribute to finding solutions to the issue of child health in the Sub-Saharan African Region as most countries in the region share similar characteristics.

In this study, data from the Ghana Demographic and Health Survey is utilised. This survey data is a rich source of information on the demographic, socio-economic and health status of the population and contains variables that offer researchers the opportunity to explore various characteristics.

Chapter 2

DEMOGRAPHIC AND HEALTH SURVEY

Demographics refer to statistical data relating to a population or a particular group within the population (Oxford Dictionary). The main source of comprehensive and detailed demographic information about the population of any country is through Population censuses. Although a rich source of information, censuses are resource intensive; expensive to implement and time consuming. Demographic information is therefore usually obtained through sample surveys since they are less expensive to implement and require relatively less time to complete. Examples of such surveys conducted in various countries are the Demographic and Health Survey (DHS), the AIDS Indicator Survey (AIS) and the Multiple Indicator Cluster Survey MICS.

2.1 Demographic and Health Surveys (MEASURE DHS)

The MEASURE Demographic and Health Surveys (MEASURE DHS) have been recognised as the most accurate source of information on the demographic and health characteristics of the population in developing countries (DHS, 2006a). They have been collecting nationally representative data on population, health, and nutrition since 1984. New topics have been added over the years to address emerging health issues, including HIV/AIDS and sexually transmitted infections, malaria, youth, female genital cutting, women's empowerment, domestic violence, tobacco and alcohol use, and hypertension (DHS, 2006a).

Sampling of the DHS involves a two-stage cluster sampling design; 1) Selection of Enumeration areas (EA) or population clusters with probability proportional to size. 2) Listing all households in each selected EA and randomly selecting the households to be interviewed with equal probability (DHS, 2006a).

The MEASURE DHS project has conducted over 300 surveys in about 90 countries (Arnold and Hancioglu, 2010). Technical support and assistance in the training of interviewers and fieldwork for the DHS is provided by staff of ICF Macro formerly known as Macro International. The United States Agency for International Development provides funds for the DHS with contributions from other international organisations such as United Nations Population Fund (UNFPA), United Nations Children's Fund (UNICEF) and the World Health Organisation (WHO). Further funding is provided by governments in some of the countries where the survey is conducted (DHS, 2009).

The main objectives of the DHS are to:

- collect data to use in policy formation, program planning, and monitoring and evaluation.
- foster and reinforce host country ownership of data collection, analysis, presentation, and use.
- coordinate with key stakeholders on data collection and dissemination.
- select the most appropriate data collection methods to ensure the provision of high-quality data at a reasonable cost.
- increase the capacity of host-country partners to collect and use data for program and policy purposes.

Since October 2008, ICF Macro has partnered with five internationally experienced organisations, Johns Hopkins Bloomberg School of Public Health/Center for Communication Programs, PATH, The Futures Institute, CAMRIS International, and Blue Raster, to expand the access and use of the DHS data (DHS, 2009).

Questionnaires for the survey follow the standardized modules of the DHS program. This allows for comparison of results across countries or within a single country chronologically over a period of time (DHS, 2009). The questionnaires are translated into recode datasets using standard recode definitions to facilitate data analysis. The reasons for translating into recode files include:

- To combine the variables and create a form easier to use in data analysis.
- To impute dates for several key events that might be missing or incomplete in order to help analysts to produce consistent results.

- To provide summary variables which are used in analysis as well as in the final reports.
- To calculate indices such as anthropometric indices from height and weight data.
- To provide data in standard format with common variable names and categories for comparison (DHS, 2009).

There are seven core recode datasets that the main questionnaires are translated into. These recode datasets include:

Household Data

This has one record for each household and includes the household member's roster. However, there is no information from the individual questionnaire in this file. The unit of analysis here is the household.

Household Member Data

This has one record for every household member. Information is collected on basic demographics such as sex, age, height and weight measurement. It also includes characteristics of the household where the individual is staying or living. The unit of measurement here is the household member.

Individual Women's Data

The Women's recode file has one record for every eligible woman, that is between 15-49 years. It contains all the data collected in the women's questionnaire as well as some variables from the household questionnaire. The birth history for up to 20 births as well as information on up to 6 children below 5 years of age is collected. Information collected include pre and post natal care, immunisation and health. The unit of measurement is the woman.

Individual Men's Data

The Men's Data has one record for every eligible man, that is between 15-59 years. It contains all the data collected in the Men's questionnaire plus some variables from the household questionnaire. The unit of analysis is the man.

Couple's Data

This has one record for every couple. It contains data for married people or men and women who are living together and have each completed the individual questionnaire. The Couple's file is a result of linking the men and women questionnaire based on whom they both had declared as partners. The unit of analysis here is the couple.

Birth Data

The Birth Recode file contains information on all children ever born to the woman who has been interviewed. It therefore provides information on the birth history of the interviewed woman. It can be used to calculate health indicators as well as the fertility and mortality rates. The unit of analysis here is the child.

Children's Data

This has all the information on all children born within 5 years preceding the survey. It has one record for every child that is between 0-59 months. It contains information related to the mother's pregnancy, the child's postnatal care, immunisation and health status. It also includes data on the mother and can be seen as a subset of the Birth recode file. The children's data can used to look at child health indicators such as vaccination coverage, vitamin

A supplement as well as the occurrences and treatment of childhood diseases. The unit of analysis is the child (DHS, 2006a).

2.2 Ghana Demographic and Health Survey

The Ghana Demographic and Health Survey (GDHS) is part of the international MEASURE DHS program which has been conducting household surveys in developing countries since 1984 (Vaessen *et al.*, 2005). The main purpose of the DHS is to provide data that is needed to monitor and evaluate health and nutrition of the population. In Ghana the DHS is conducted every five years and the first round was conducted in 1988 between February and June (GSS and Macro, 2009).

The main objectives of the survey have been revised over subsequent years to provide information on marriage, sexual activity, awareness and behaviour regarding AIDS and other sexually transmitted diseases (STD's), awareness of tuberculosis, domestic violence, childhood mortality and breastfeeding practises (GSS and Macro, 2009). Also, recent GDHS provides comparable data since it is implemented by same organisation using similar data collection procedures. This makes it possible to do a long term trend analysis in the country. It also strengthens the capacity of the Ghana Statistical Service (GSS) to plan, conduct, process and analyse data from a complex large-scale survey (GSS and Macro, 2009).

The first round of the GDHS was funded mainly by the United States Agency for International Development (USAID) and the Government of Ghana with support from United Nations Fund for Population Activities (UNFPA) and the United Nations Children's Fund (UNICEF). The survey was carried out by the Ghana Statistical service over a four month period. Subsequent surveys have received support from other donors including the Ghana AIDS Commission (GAC) and the Danish Development Agency (DANIDA). The survey is now carried out by the Ghana Statistical Service in collaboration with the Ghana Health Service (GHS) (GSS and Macro, 2009).

The 1988 GDHS used a sample of 4966 households selected nationwide. Also, there were 4574 women selected for the individual/women interview and 997 men selected for the husband interview. These men were the husbands of women who have been successfully interviewed in half of the selected clusters. In the next survey carried out in 1993, an innovation was introduced to include a subsample of all men aged 15-59. Subsequent surveys included a much larger nationally representative sample and in the most recent survey, a sample of 12,323 households was used. Also, a total of 4,916 women and 4,568 men in half of the sampled households were also interviewed (GSS and Macro, 2009).

The core content of the GDHS follows the standard of the international MEASURE DHS so as to maximise information comparability. There are however certain modules that address issues of particular importance to the country. The main questionnaires used in the GDHS are the Household questionnaire, Women's questionnaire and the Men's questionnaire. The entire questionnaires are adapted from the Model "B" Questionnaire for the DHS program.

The Household questionnaire is used to obtain data on all usual members and visitors in the selected households. Visitors are defined as all those who spent the night prior to the interview day. Basically, the household questionnaire is used to record demographic data on the respondents and also collect data on their health and disability status. From the 2003 GDHS, the Household questionnaire was used to collect data on the ownership and use of mosquito nets. It was also used to record the consent of respondents to haemoglobin and HIV testing. For the 2008 GDHS, the Household questionnaire was used to record all the deaths of household members that had occurred since January 2003. One main purpose of this questionnaire is to identify eligible men and women for the individual interviews.

The Women's Questionnaire is used to collect data on all women aged 15-49 in half of the selected households, whether they were usual members or not. They were asked questions about themselves and about their children who were born within the last five years prior to the survey.

The Men's Questionnaire was also administered to all men who were between the ages of 15-59 in half of the selected households. The information obtained was the same as that obtained from the women but did not include a reproductive history or questions on maternal or child health and hence was shorter (GSS and Macro, 2009).

Further information on the GDHS can be found in the 2008 GDHS report which is available from the Ghana Statistical Service, ICF Macro or the USAID.

The main objective of this thesis is to investigate the nutritional status and the prevalence of anemia in children under the age of five (5) in the Ghanaian population. In view of this target population, the main dataset used in this research is the Children's Data recode dataset of the 2008 GDHS, which is the most recent demographic and health survey conducted in the country. The next one is currently under way and it will be interesting to examine the trend of malnutrition and anemia over the period.

2.3 Growth and Development of Children in Ghana

In Ghana, there has been an increase in the efforts being made by governmental and non-governmental agencies to tackle child health issues (Ghana News Agency, 2009; Van de Poel *et al.*, 2007). This is due to the advancement in child health research and the creation of initiatives which have led to an improvement in child health over the years. However, there is more room for improvement from the current estimates. According to the Ghana Health Service (GHS) 2012 report, a total of 12000 children were estimated to die annually due to underweight while 97000 children are expected to die between 2011 and 2020 due to stunted growth if current trends are not improved (Ghana News Agency, 2012).

Between 2000-2003, the main causes of under 5 mortality in Ghana were malaria (33%), neonatal causes (28%), pneumonia (15%) and diarrhoea (12%) (UNICEF 2006). Protein Energy Malnutrition (PEM) which causes underweight and growth retardation is associated with about 54% of death beyond infancy (Van de Poel *et al.*, 2007). In other words, PEM is the single greatest cause of child mortality in Ghana. There are 3 indices used in describing the nutritional status of children; stunting, wasting and underweight. Of these three indices, stunting is the most prevalent in Ghanaian children who are under the age of 5. More than a quarter of the children, 28% are estimated to be stunted with 10% being severely stunted. Also, 9% are wasted and 14% are underweight (GSS and Macro, 2009). The prevalence of anemia is extremely high with approximately 78% of the children under age 5 being anemic.

There has been several research into the nutritional status of children in Ghana. Amugsi *et al.* (2013) studied the trends in child malnutrition in children aged 3 years and under between the period 1993 to 2008 using the Ghana Demographic and Health Survey data. They observed a significant decline in trends at the national level for wasting, underweight and stunting. They further observed a significant decline in trends for stunting and wasting for the male children but not for the female children. They also observed that while the trends in malnutrition among poorest children declined over the period, the trend among rich children was static. One interesting observation was the increasing trend in the prevalence of stunting for children whose mothers had higher than primary education.

In examining the environmental correlates with childhood height-for-age in Ghana, Nikoi and Anthamatten (2013) used data from the 2008 GDHS and the 2000 Population and Housing census. They used generalised linear models to estimate the effects of individual and environmental correlates on stunting (height-for-age). They found out that stunting in children is associated with the age of the child, the vaccination status, the birth weight and the months of breastfeeding. They also observed that maternal factors such as the body mass index (BMI), ownership of National Health Insurance and wealth had a direct effect on stunting. Finally, after they accounted for characteristics such as urbanisation and district-wide poverty, population density was found to be associated with height-for-age (stunting).

A study by Anderson *et al.* (2010) which examines the risk factors of malnutrition among children aged 5 years and younger in the Akwapim-North district in the Eastern region of Ghana showed that stunting and anemia are the most prevalent in the area. The observed prevalence of stunting and anemia were 11.4% and 80.7% respectively. Using the Pearson Chi-Sq test, they found exclusive breastfeeding, age of child, having electricity in the house and the ownership of radio to be associated with different forms of malnutrition. Another study done by Appoh and Krekling (2005) in the Volta region to investigate the nutritional status of young children revealed that mother's knowledge on adequate nutrition and appropriate breastfeeding practices, and marital status were associated with malnutrition in children.

Koram *et al.* (2000) studied severe anemia in children aged 6-24 months in the Kassena-Nankana district of the Northern region. It was a longitudinal study where the haemoglobin levels of the children were measured after high and low malaria transmission seasons. Their findings showed that the prevalence of severe anemia was high at the end of the wet season, that is the high malaria transmission season than the low transmission season, 22.1% vs. 1.4% respectively.

This study analyses the nutritional status of children under the age of 5 in the Ghanaian population using the prevalence of malnutrition and the prevalence of anemia. The association between the various factors and the nutritional status of young children is also investigated. This is to find out if factors that have been identified in studies, especially in other parts of the world, to be associated with nutritional status are significant in the Ghanaian setting. Finally, subgroup analyses is performed to identify true prevalence that may have been masked by national and regional estimates.

Chapter 3

ANALYSIS OF HEALTH SURVEYS

Health surveys make it possible to study the association between risk factors and health outcomes. However, the complicated nature of these surveys especially with the sampling design coupled with the differential probabilities of sampling individuals makes the analysis of health surveys challenging. Many questions have been raised in relation to the appropriate analysis to perform and there have been several theoretical and empirical work in that regard (Korn and Graubard, 1995). Findings from health surveys nevertheless can be made representative of a target population if the right statistical methods are used in the analysis.

3.1 Sampling Design of Health Surveys

Health Surveys involving a large number of individuals typically use stratified multi-stage cluster sampling designs. The main sampling methods used in most health surveys are Cluster sampling, Stratified sampling and Systematic Sampling.

Cluster Sampling

With cluster sampling, the population is divided into N distinct groups called clusters. A total of n clusters are then selected randomly to be included in the sample. The number of observations, M_i in each selected cluster is known. The total number of observations in the sample is,

$$M_1 + M_2 + ... + M_n = M$$

Two types of cluster sampling are the single-stage sampling and the multi-stage sampling. With the single-stage cluster sampling, all elements in a cluster are included in the sample. The two-stage cluster sampling which is the simplest form of the multi-stage sampling involves randomly selecting elements in the selected clusters to be included in the sample (Cochran, 2007).

Stratified Sampling

Stratified sampling involves two steps. First, the population of N units is divided into non-overlapping sub-populations of $N_1, N_2, ..., N_L$ units which comprise the whole population. That is,

$$N_1 + N_2 + ... + N_L = N$$

These sub-populations are called strata, hence the name of the sampling method. For the second step, independent samples are drawn from each strata. The sample sizes in each strata are denoted by $n_1, n_2, ..., n_L$ respectively. If the samples are drawn using simple random sampling, then the procedure is called stratified random sampling (Cochran, 2007).

The main difference between cluster sampling and stratified sampling is that, with cluster sampling, the clusters are the primary sampling units whiles with stratified sampling, the elements in the strata are the primary sampling units. Thus with stratification, all the strata are represented in the sample whiles with clustering, only a subset of the clusters are represented in the sample.

Systematic Sampling

In systematic sampling, the number of units in the population are numbered 1 to N in some order. To select a sample of size n, a unit $k = N/n$ is taken at random from the first k units and then every kth unit thereafter. Instead of starting the sequence with a random number between 1 and k, one variant of the systematic sample is to choose each unit at or near the center of the stratum. The starting number is taken as

$$\frac{k+1}{2},$$

if k is odd and

$$\frac{k+2}{2}$$

if k is even.

This method usually results in unequal sample sizes depending on the starting number. Another method that results in a constant sample size and an unbiased sample mean involves regarding the N units as units arranged in a circle. Then starting from a random number between 1 and N, every kth unit is selected, going round in the circle until the desired n units have been chosen (Cochran, 2007).

3.2 Types of Health Surveys

There are different types of common health surveys. These include institutional surveys, household interview surveys, telephone surveys and follow back surveys.

Institutional Surveys

These types of surveys use a two-stage sampling design. The primary sampling units are the institutions, for instance hospitals. The main reasons for the two-stage design is to lessen the number of institutions that need to be sub-sampled and also to avoid constructing a sampling frame for the entire population. Stratified sampling can be used in the selection of institutions with different probabilities based on some characteristics. This is usually to lessen the level of variability of estimators. Stratification can also be used in the selection of elements within the selected institutions using the individual characteristics. This allows for oversampling of certain population to provide key estimates (Graubard and Korn, 1996).

Household Interview Surveys

These surveys are the most common type of health surveys. Usually uses multi-stage cluster sampling to select the samples. The primary sampling units (PSU) are the geographic areas, e.g. cities, counties or enumeration areas. For each sampled PSU, further sub-sampling involving smaller geographic areas such as census districts within the PSU, neighbourhoods within census districts, households within neighbourhoods or individuals within households is performed. Multi-stage sampling has several advantages which include, lessen the number of areas to which interviewers must travel and also to make it easier to construct a sampling frame. Stratified sampling can again be used at each stage of the multi-stage cluster sampling to select the sample units (Graubard and Korn, 1996).

Telephone Interview Surveys

Telephone surveys basically use a two-stage design and involves some form of random digit dialling. The commonly used method is the Mitofsky-Waksberg scheme which involves: 1) Selecting a sample of telephone exchanges and 2) Sampling telephone numbers within the exchange and calling the numbers. If there is a success in calling, other numbers in the exchange are tried, otherwise, another exchange or the next exchange is sampled.

The other most recent method is the list assisted random digit dialling technique which uses computerised list of exchanges. These lists usually contain additional information on the exchange making it easier to implement a stratified random sampling of telephone numbers within an exchange. The strata is determined by the exchange variables (Graubard and Korn, 1996).

3.3 Weighting Health Survey Data

Sampling units in health surveys are usually included with unequal probabilities and hence the sample is not self-weighting. Other issues such as non-response and non-coverage of populations contribute to imperfections in the sample that lead to bias and/or departures from the reference population (Yansaneh, 2005). To rectify these discrepancies, sampling weights are needed. Sample weights are basically the inverse of the inclusion probability and effectively represent the number of units in the population that the sampled unit represents. Weighting is also important in making inferences. The main purpose of weighting is to:

- compensate for unequal probabilities of selection
- compensate for non-response of sampling units
- adjust the weighted sample distribution for key variables of interest, e.g age, to make it conform to a known population distribution (Yansaneh, 2005).

3.3.1 The Weighting Procedure

Development of sampling weights begin with the construction of the base weight for each sampling unit. The base weight is the reciprocal of the selection probability. Thus, if the unit is included in the sample with probability p_i, then the base weight, $w_{i,b}$ of the ith unit is given as;

$$w_{i,b} = \frac{1}{p_i}$$

A sampled unit selected with probability 1/20 has a base weight of 20, that is, the sampled unit represents 20 units in the population from which the sampled unit was drawn. The sampled weights therefore act as inflation factors. The sum of the weights gives an unbiased estimate of the total number of individuals in the reference population (Korn and Graubard, 2011; Yansaneh, 2005).

In a multi-stage sampling, the inclusion probability at each stage must be reflected in the base weight. The overall inclusion probability is therefore, the inclusion probability at the first stage multiplied by the conditional inclusion probability from later stages of sampling.

For a two-stage sampling design for instance, the ith primary sampling unit (PSU) is selected with probability p_i at the first stage and the jth household is selected within the PSU with probability $p_{j(i)}$ at the second stage. The overall inclusion probability is therefore calculated as

$$p_{ij} = p_i * p_{j(i)}$$

The base weight, $w_{ij,b}$ of the household is therefore the inverse of the inclusion probability p_{ij}. When making sub-group comparisons, then base weights may be enough. However, for population based conclusions, it is imperative to incorporate other forms of weights (Korn and Graubard, 2011; Yansaneh, 2005).

Non-response is one major issue in health surveys since it is rarely the case that all desired information is obtained from all sampled units. Non-response could either be total/unit non-response, where households may provide no data at all, or item non-response where some provide only partial data. It leads to bias especially when there are systematic differences between respondent and non-respondent groups.

Item non-response is usually compensated using imputation which is the standard method. For total non-response, three main procedures used are: 1) Non-response adjustment of weights, 2) Drawing a larger sample than needed and creating a reserve sample from which replacements are selected, 3) By substitution where a household in close proximity with a non-response household is selected to replace the non-responding household (Yansaneh, 2005).

In major household surveys in the world, the most preferred method used to compensate for total non-response is non-response adjustment weights. This is a product of the non-response adjustment and the base weight. The non-response adjustment is the inverse of the proportion of people that responded in the survey. The non-response adjusted weight for the ith unit is calculated as

$$w_i = w_{i,nr} * w_{i,b}$$

where $w_{i,nr}$ is the non-response adjustment and $w_{i,b}$ is the base weight. The non-response adjustment can be defined as the ratio of the weighted number of completed interviews in sampled households to the weighted total number of sampled households (Korn and Graubard, 2011; Yansaneh, 2005).

Non-coverage is another major issue in household surveys. Non-coverage occurs due to failure of the sampling frame to cover all units in the target population. It may occur at all levels, that is the PSU level, household level and the individual level. The standard procedure used to handle non-coverage is known as the post-stratification adjustment. The adjustments correct inadequacies of sampling frame where there may be no information from some people who should have been in the sample. One purpose of the post-stratification components is to lessen variability of estimates. It simultaneously compensates for non-response and non-coverage. Raking is one method of post-stratification. The post-stratification adjustment is the ratio of the total known number of households to the weighted sample total.

For the two-stage sampling example mentioned earlier for instance, the overall weight of the jth household in the ith PSU is calculated as

$$w_{ij} = w_{ij,b} * w_{ij,nr} * w_{ij,nc}$$

where $w_{ij,b}$ is the base weight, $w_{ij,nr}$ is the non-response adjustment and $w_{ij,nc}$ is the post-stratification adjustment (Korn and Graubard, 2011; Yansaneh, 2005).
Although sample weights reduce the bias in the survey estimates, they are often highly variable and may result in substantial inflation of the variance of a survey estimate. When this variation in the weights is harmful for estimation, weight truncation is applied. The methods of weight truncation that are often used include Taylor Series Procedure, Weight Distribution Procedure, Estimated MSE Procedure and the NAEP Procedure. Weight truncation is beyond the scope of this present study, however further information on weight truncation can be found in other literature (Potter, 1990).

Chapter 4

ANALYSIS OF GHANA DEMOGRAPHIC AND HEALTH SURVEYS

The Ghana Demographic and Health Survey (GDHS) which is a household survey is utilised in this thesis. Household surveys as mentioned in the previous chapter are the most common type of health surveys.

4.1 Sampling Design of the Survey

Sampling in the GDHS involves a stratified two-stage cluster sampling design. The major domains in the GDHS were the country, regions and locality (Urban and Rural). Three main sampling procedures are used; stratification, clustering and systematic sampling. The primary sampling unit (PSU) was the cluster defined on the basis of Enumeration areas (EA) from the population and housing census frame. Each cluster contains at least one EA.

The EAs were stratified first by urban and then by rural areas. The clusters were then selected using systematic sampling with probability proportional to size, apart from the Upper East and West regions. The number of clusters in each region was calculated by dividing the total number of allocated households by a sample take of 15 which is the number of households per EA. For the Upper East and West regions, the proportion of EAs was twice the proportion used in the census proportional population distribution. A total of 412 clusters which consisted of 182 clusters in urban areas and 230 clusters in rural areas were selected. A complete household listing was then done to provide a sampling frame for the second stage which involved using systematic sampling to select 30 of the households listed in each cluster. This stratified two-stage design was used to obtain a sample large enough to provide separate estimates for key indicators in each of the ten regions in Ghana with acceptable precision (GSS and Macro, 2009).

4.1.1 Weighting the Ghana Demographic and Health Survey

Since the sample was not proportional to the population by urban-rural residence area and region, it was not a self-weighting sample. Sample weights were applied in order to compensate for the unequal probability of selection between the strata that has been geographically defined as well as for non-response. For the GDHS, two sampling weights are calculated. These are the Household weights and the Individual weights. The other rates calculated are the household response rate and the individual response rate (GSS and Macro, 2009).

The household weight (W_H) for a particular household is the inverse of the selection probability multiplied by the household response rate (R_H) of its household response rate group. That is,

$$W_H = \frac{N}{n} * \frac{1}{R_H}$$

where N is the population size and n is the sample size. Also, the individual weight (W_I) is the household weight multiplied by the individual response rate of its individual response rate group. That is,

$$W_I = W_H * \frac{1}{R_I}$$

The household response rate (R_H) is calculated as

$$R_H = \frac{C}{C + HP + R + DNF + P}$$

where

C: number of households with completed interveiws

HP: number present but no competent respondent at home

R: number that refused to be interviewed

P: number that permanently postponed the interview

DNF: number of households for which dwelling was not found.

The individual response rate (R_I) is also calculated as

$$R_I = \frac{IC}{IC + INP + IR + IP + IPC + IN}$$

where

IC: number of eligible individuals with completed interveiws

INP: number of eligible individuals not present at home to be interviewed

IR: number who refused to be interviewed

IP: number who permanently postponed the interview

IPC: number with partially completed interviews

IN: number of individuals for whom the interview could not be completed due to incapacitation or other reasons.

The initial weights were produced using the sample selection probabilities of each household and the household as well as individual response rates. The initial weights were standardized by dividing each weight by the average of the initial weights (Vaessen *et al.*, 2005; GSS and Macro, 2009).

4.2 Measurement of Nutritional Status

In accordance with the aim of this study, we assess the nutritional outcomes of the children. Nutritional outcomes are measured by various indices including weight-for-age, height-for-age, weight-for-height, growth rates, head circumference, mid-upper arm circumference and triceps skin-fold thickness, iron deficiency, vitamin A deficiency and iodine deficiency.

For this study, the three most common anthropometric measures used in several studies and that provide a comprehensive profile of the nutritional status of children were used; stunting, wasting and underweight. These were measured by the indices height-for-age, weight-for-height and weight-for-age respectively. Also, micro-nutrient deficiency was assessed by the level of anemia which was measured by the haemoglobin concentration in the blood. Haemoglobin concentration is examined because the prevalence of anemia in young children in the country is well above the World Health Organisation threshold of 40% considered as a severe public health issue.

In assessing the nutritional status of the children under the age of 5, their height/length and weight were measured during the 2008 demographic and health survey. The weights were measured using a lightweight, electronic Seca scales with a digital screen. The height measurements were carried out using a measuring board. For children younger than 2 years, their recumbent length (measured while lying down on the board) were taken while the standing height of the older children was measured (GSS and Macro, 2009). The new WHO reference standard was used to calculate the indices of malnutrition.

In half of the households selected for the survey, the eligible women, that is women aged $15-49$ years as well as children aged 6-59 months were tested for anemia. This was done by testing their haemoglobin level using the Hemocue system. Before taking the blood, the finger was wiped with an alcohol prep swab and allowed to air-dry and then the palm side of the end of the finger was pricked with a sterile, non-reusable, self-retractable lancet and a drop of blood collected on a HemoCue microcuvette. This serves as a measuring device and its placed in a HemoCue photometer which displays the results. For children younger than one year who were undernourished and bony, a heel puncture was made to draw the drop of blood (GSS and Macro, 2009).

The malnutrition analysis for this study involves 2,379 children aged 0-59 months whiles the anemia analysis was based on 2168 children aged 6-59 months. All children with missing or flagged data on any of the primary outcomes were excluded. The height-for-age, weight-for-height and weight-for-age data were missing or flagged for 20.5% of the children and data on the haemoglobin concentration was flagged or missing for 27.5% of them.

4.3 Primary Outcomes

The primary outcomes that were used in this analysis are:

Height-for-age

Height-for-age has been identified as the most reliable indicator of the nutritional status of children since it is less sensitive to temporal food shortages and season of data (Fotso, 2007). In the survey, height-for-age was measured as a continuous variable ranging from -5.90 to 5.92. However, in recent studies it is treated as a categorical variable (Babatunde *et al.*, 2011; Van de Poel *et al.*, 2007; Hong, 2007). Children whose height-for-age z-scores (HAZ) are below -2 standard deviations (SD) from the median of the WHO reference population standard are considered as stunted whiles children whose HAZ are below -3 standard deviations from the median of the reference population are considered severely stunted. For the purposes of this study, the HAZ was categorized into stunted (HAZ $<$ -2SD) and not stunted (HAZ $\geq$ -2SD). The stunted category thus includes both moderately as well as severely stunted children.

Weight-for-Height

Weight-for-height is a measure of under-nutrition over a short period of time and usually due to the incidence of infections, low/inappropriate food consumption or food shortage (Anderson *et al.*, 2010; Babatunde *et al.*, 2011). It is also referred to as the body mass index in relation to the body length. It is the commonly used index in emergency cases to assess nutritional deficiency when the age of the child is unknown (Babatunde *et al.*, 2011). Similar to stunting, weight-for-height was measured as a continuous variable that ranges from -4.93 to 4.70, however it is treated as a categorical variable in recent studies (Anderson *et al.*, 2010). Children whose weight-for-height z score (WHZ) fall below -2 standard deviations (SD) from the median of the reference population are considered to be wasted whiles children whose WHZ fall below -3 standard deviations from the median of the reference population are considered severely wasted. In this study, WHZ is categorised into wasted (WHZ $<$ -2SD) and not wasted (WHZ $\geq$ -2). Thus the wasted category includes both the severely wasted and the moderately wasted children.

Weight-for-age

The weight for age is a composite index that refers to being either stunted or wasted or both. It is the second most prevalent form of malnutrition in Ghanaian children (GSS and Macro, 2009). Just like the other two indices of malnutrition, weight for age was captured as a continuous variable ranging from -5.29 to 4.58. In most studies however, the weight for age index is analysed as a categorical variable (Babatunde *et al.*, 2011). Children with weight for age z score (WAZ) below -2 standard deviations (SD) from the median of the reference population are considered as underweight whiles those with WAZ below -3 standard deviations from the median of the reference population are considered severely underweight. For this study, children with WAZ below -2SD are categorised as underweight whiles children with WAZ at or above -2SD are classified as not underweight.

Haemoglobin Concentration

The anemic status of the children were assessed using the concentration of haemoglobin (Hb) in their blood. This is similar to what is done in most studies (Bernard, 2013; Villalpando *et al.*, 2003; Hedberg *et al.*, 1993). The haemoglobin concentration was measured as a continuous variable in the demographic and health survey. Although altitude has an effect on the concentration of haemoglobin in the blood, none of the children were living more than 1000m above sea level. Hence the haemoglobin concentrations were not adjusted for altitude.

For the purposes of this study, children were classified as anemic when their Hb concentration is greater than or equal to 11.0g/dl and not anemic otherwise. In assessing the severity of anemia, the cut-off values used were: $<$ 7.0g/dl for severe anemia, 7.0g/dl-9.9g/dl for moderate anemia and 10.0g/dl-10.9g/dl for mild anemia. All the cut-off values used in this study is in accordance with the WHO recommended cut-off values.

4.4 Factors Associated with Childhood Nutrition

A large number of variables have been associated with the measures of nutritional status discussed above. Among these variables are age of child, gender, vaccination status, duration/months of breastfeeding and breastfeeding status, the incidence of co-morbidity diseases, mother's education, age at first childbirth, body mass index, marital status, wealth, size of household, place of residence, region of residence, water and sanitation, access to public services, electricity supply and immigration (Amugsi *et al.*, 2013; Bernard, 2013; Nikoi and Anthamatten, 2013; Zhao *et al.*, 2012; Van de Poel *et al.*, 2007; Fotso, 2007; Hong, 2007; Glewwe, 1999; Cornet *et al.*, 1998; Horton, 1986).

Although GDHS collected information on a large number of variables including demographic, social, economic, and geographical characteristics, not all the variables that have been identified as relevant were available in the 2008 GDHS. In another sense, not all variables available in the GDHS data were relevant to this study. Furthermore, only those variables that were identified as significant in most of the literature reviewed were included in this study. The variables are classified under child factors, maternal factors and socio-demographic factors. The conceptual framework depicting the classification of these factors is shown in Figure 4.1.

4.4.1 Child Factors

The child factors that are considered in our analysis are:

Age of Child

The current age of the child has been identified to be significantly associated with nutritional status of the child. The reason for this is that the age of the child affects not only the type of food consumed but also the quantity of food. Several studies have shown that deficit in growth is not significant until after 6

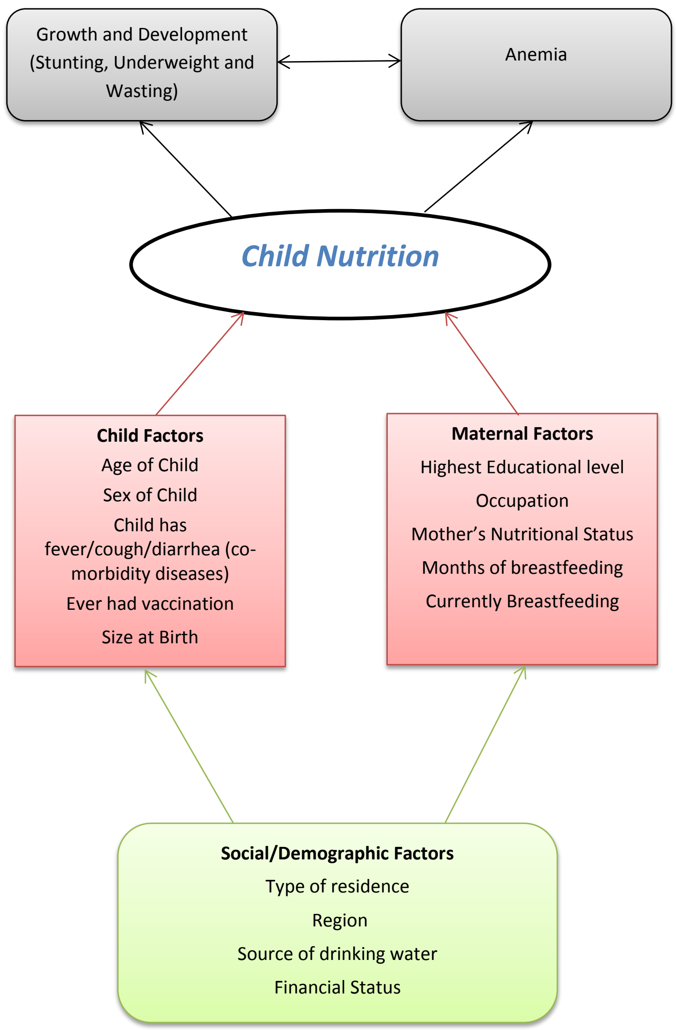

Figure 4.1: *Conceptual Framework*

months when most children are introduced to complementary feeding and then increases rapidly after 12-18 months when most are weaned (Van de Poel *et al.*, 2007; Alderman and VK, 1990). In this study, the chronological age of the child is categorised into 5 subgroups; 0 or 6 months-11 months (0 or 6 months $\leq$ age < 1), 12-23 months ($1 \leq$ age < 2), 24-35 months ($2 \leq$ age < 3), 36-47 months ($3 \leq$ age < 4) and 48-59 months ($4 \leq$ age < 5). In assessing the prevalence of anemia, the age of the child is also categorised into 2 subgroups, less than 2 years old and 2 to less than 5 years old. This is similar to what is found in literature (Bernard, 2013; Cornet *et al.*, 1998).

Sex of Child

The sex of the child has been found to have an effect on their nutritional status. In some studies done in Ghana, boys have been observed to be at a higher risk of malnutrition than girls (Van de Poel *et al.*, 2007; Hong, 2007). These findings interestingly contradicts the long held conviction that boys are mostly preferred to girls especially in developing countries. In this study, the sex of the child is categorised as male and female. Results from this study will either confirm the earlier findings or dispute it.

Co-morbidity Diseases

Another variable that has been identified as a determinant of childhood nutritional status is the incidence of co-morbidity diseases. Children who are suffering from an infection/disease are at a higher risk of being malnourished or deficient in nutrients (Wahlqvist and Lee, 2006; Victora *et al.*, 2003). In the study, incidence of co-morbidity categorised as “Had an infection” is coded as “Yes” if the child had at least one of the three diseases: diarrhea, fever or pneumonia in the last two weeks preceding the survey and “No” otherwise.

Vaccination

Vaccination information in the GDHS was obtained from either the health card of the mother or by verbal report if the health card was not available. The types of vaccines available in the country are; a dose of BCG and measles as well as 3 doses of DPT and Polio. This is in accordance with the WHO and UNICEF guidelines and all children are expected to have completed the vaccination schedule by 12 months of age (GSS and Macro, 2009). Vaccination was categorised as a dichotomous variable, where “Yes” means the child had ever been vaccinated and “No” if the child had not received any of the vaccines.

Birth Weight

The weight of a child at birth is significantly associated with increased risk of infections, diseases as well as mortality. Children with low birth weight have an increased exposure to infections and diseases and are also more likely to die before their 1st birthday (Nikoi, 2011). In the 2008 GDHS, birth weight were reported based on written records or mother’s recall. This is because some babies were born outside a health facility where they are more likely to be weighed (GSS and Macro, 2009). In order to reduce the likelihood of error and/or bias in weight estimates given by mothers, the birth weight used in this study was the categorical subgroups which is originally coded as “size at birth” in the 2008 GDHS. For ease of interpretation, the birth weight was recoded into 3 categories: Large, Average and Normal.

4.4.2 Maternal Factors

The following maternal factors are investigated in our analysis:

Educational Level

One variable that has been significant in almost all studies of the nutritional status of children is the educational level of the mother. Educated mothers are better informed on the knowledge and use of health facilities, appropriate infant and young child feeding practices and better sanitation practices (Babatunde *et al.*, 2011; Amsalu and Tigabu, 2008; Glewwe, 1999). The educational system in Ghana comprises of 6 years of primary school, 3 years of junior secondary/high school, 3 years of senior secondary/high school and a minimum of 3 years of tertiary education. The educational level of the mother as categorised in the survey was used in the analysis. The categories were; "No education" if the mother has had no form of formal education, "Primary", for some form of primary education, "Secondary" for some form of secondary education and "Higher" for some level of post-secondary (tertiary) education. Other studies used the same classification (Andoh *et al.*, 2007; Fotso, 2007).

Nutritional Status

The body mass index (BMI) defined as the ratio of the weight in kilograms to the square of the height in meters (kg/m^2) was used to measure the nutritional status of the mother similar to what is found elsewhere (Babatunde *et al.*, 2011; Rahman and Chowdhury, 2007). A mother whose BMI is $< 18.5kg/m^2$ is categorised as being malnourished (underweight) whiles a mother whose BMI is $\geq 25kg/m^2$ is overweight and a mother whose BMI is $\geq 30kg/m^2$ is obese. These are the WHO standard cut-off values. For this study, BMI was categorised as "malnourished" if the BMI is $< 18.5kg/m^2$ "not malnourished" otherwise. The reason for this classification was because of the studies by Babatunde *et al.* (2011) where it was observed that probability of stunting decreases with higher values of BMI.

Occupation

In the demographic and health survey, respondents were asked about their employment status in the last year preceding the survey. Respondents who had performed any form of work in the past year were considered as employed. The 2008 GDHS classified employment into 10 categories. Based on the purpose and setting this study, mother's occupation was classified into 5 subgroups; "Not working" for respondents who responded not working to the question of employment status, "Agricultural" for those who were in either self-employed or employees in agriculture, "Manual" for respondents who were involved in either skilled or unskilled manual, "Clerical/Services" for respondents in clerical, household/domestic, sales or services profession and "Professional/Managerial" for respondents in either category.

Breastfeeding Status

The duration of breastfeeding is another determinant of malnutrition that has been found in literature (Hong, 2007; Vella *et al.*, 1992). For this study, the duration of breastfeeding was classified as "at least 18 months" and "more than 18 months". This classification is based on a study by Brakohiapa *et al.* (1988) where they reported 18 months as the recommended age to wean children in Ghana. In examining the prevalence of anemia, the effect of current breastfeeding status of children aged 2 years or less was investigated.

4.4.3 Socio-economic factors

The socio-economic factors that were incorporated in our analysis are as follows:

Wealth

The financial status of the household is another common determinant of all forms of malnutrition. Wealth is measured using household assets as recommended by recent research. Furthermore, the World Bank supports the use of household assets to measure wealth due to the unreliability of income measures in poor resource contexts (Nikoi and Anthamatten, 2013). In the 2008 GDHS, all mothers and children are assigned a standardized wealth index score.

Wealth index is defined as a composite measure of a household's cumulative living standard. It is calculated based on household ownership of selected assets such as televisions and bicycles; materials used for the housing construction; source of drinking water; and type of sanitation facilities. The wealth index is then generated using principal components analysis and the individual households were placed on a continuous scale of relative wealth (DHS, 2006b). The wealth index is divided into wealth quintiles; poorest, poor, middle, rich and richest. For this analysis, wealth (financial status) was grouped into 3 categories: Rich, Middle, and Poor. This was to facilitate interpretation.

Source of drinking water

Access to clean water is found to be negatively correlated to all forms of nutrition deficiency (Babatunde *et al.*, 2011; Smith *et al.*, 2005). Access to clean drinking water decreases the risk of water-borne diseases such as cholera, diarrhea and typhoid. The most common source of drinking water especially in the rural areas was borehole/well (GSS and Macro, 2009). Only a small proportion of the households however treat their water before drinking leading to an increased risk of severe health problems especially in children. In the study, the source of drinking water is categorised into 5 subgroups based on the 19 categories in the GDHS; pipe borne, borehole/well, mineral water (includes bottled and sachet water), surface/natural (includes rivers, streams and springs) and other sources (such as rain water and tanker trucks).

Region/Place of residence

Disaggregating data is relevant in analysis of child nutritional status since national and regional estimates have a high likelihood of concealing deviations from the general trends within subgroups in national or regional levels (Amugsi *et al.*, 2013). In this study, the prevalence of malnutrition and anemia is investigated by place of residence; Urban or Rural and also by region, using the geographical regions originally used in the GDHS. Ghana is divided into 10 administrative regions. Within the regions and place of residence, further subgroup analysis by age and/or gender is performed to observe differentials in prevalence within region or place of residence.

4.5 Statistical Analysis of Ghana Demographic and Health Survey

In examining the proportion of malnourished and anemic children in the Ghanaian population, the association between the various risk factors and the primary variables, anemia, stunting, underweight and wasting was also analysed.

In estimating the proportion, the calculated weights were applied and the percentage of affected individuals in each subgroup was found. The proportion was calculated as

$$\bar{y}_w = \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i}$$

$y_i = 0, 1$ depending on whether the sampled case is in the subgroup or not and w_i is the final sample weight of the sampled case (Korn and Graubard, 2011).

The confidence interval for the proportion is also calculated as

$$CI = \bar{y}_w \pm t_d(1 - \alpha/2)(v\hat{a}r(\bar{y}_w))^{1/2}$$

where $t_d(1-\alpha/2)$ is the $1-\alpha/2$ quantile of a t-distribution with d degrees of freedom. For the multi-stage design, the degrees of freedom d is set to be equal to,

$$d = n(PSU) - L$$

where L is the number of strata. For un-stratified selection of PSU, the degrees of freedom would be $n(PSU) - 1$ (Korn and Graubard, 2011).

The variance of the estimated weighted proportion, $\bar{y}_w$ is calculated as

$$\begin{aligned} var(\bar{y}_w) &= \frac{\sum_{i=1}^{n} w_i y_i^2}{\sum_{i=1}^{n} w_i} - \left(\frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i}\right)^2 \\ &= \frac{\sum_{i=1}^{n} w_i (y_i - \bar{y}_w)^2}{\sum_{i=1}^{n} w_i} \end{aligned}$$

The Chi-sq test was used to investigate the relationship between the primary outcomes and the risk factors. The Chi-square test of independence is a non-parametric test that is used to determine whether the association between two categorical variables in a sample is likely to reflect real association between those two variables in the population. The chi-squared test statistic is;

$$\chi^2 = \frac{(O_{ij} * E_{ij})^2}{E_i j} \sim \chi^2_{(r-1)(c-1)}$$

where O_{ij} is the observed cell frequency, E_{ij} is the expected cell frequency, r is the number of rows and c is the number of columns (Daniel *et al.*, 1995).
The null hypothesis of no significant association between the variables being tested is rejected for large values of the test statistic or when the $p - value$ of the test statistic is less than 0.05. The chi-squared trend test was also used to investigate if there was significant trend in the difference in proportions showed by the variables that follow an ordered category, such as wealth and education. This test uses more information about the experimental design.

In calculating the chi-square trend, a score x_j is allocated to the jth column (the ordered variable) such that $x_1 < x_2 < ... < x_k$. The x_j are chosen to be equally spaced and centred around zero. The test statistic for the chi-square trend is;

$$\chi^2 = \frac{E_{xp}^2}{E_{xx}\bar{p}\bar{q}}$$

where

$$E_{xp} = \frac{\sum_{j=1}^{k} a_j x_j - \sum_{j=1}^{k} a_j \sum_{j=1}^{k} n_j x_j}{N}$$

and

$$E_{xx} = \frac{\sum_{j=1}^{k} n_j x_j^2 - (\sum_{j=1}^{k} n_j x_j)^2}{N}$$

N is the total sample size

n is the sample size of jth column

a is the number with infection

b is the number without infection

$\bar{p} = \sum a/n$ and $\bar{q} = \sum b/n$ (Armitage, 1955).

The chi-square trend tests departures from linearity. Large values of the test statistic means that there is no significant linear trend in the differences observed. The differences therefore could be due to other factors hence further investigation is needed.

Chapter 5

PREVALENCE OF MALNUTRITION IN CHILDREN

5.1 Child Factors

The analysis as mentioned in the previous chapter is based on weighted data. Out of the total of 2379 children that were included in this analysis aged $0-59$ months, approximately 50.1% (1193) were males and 49.9% (1186) were females. The mean age of the respondents was 28.78 ± 17.1 months. 20.9% of the respondents were less than a year old, 21.5% were aged 1 year to less than 2 years old, 19.3% were aged 2 to less than 3 years, 18.2% were aged 3 to less than 4 years old and 20.2% were aged 4 to less than 5 years old. Approximately 41.8% of the children had an infection 2 weeks prior to the survey. Also, only 527 children out of the total of 2379 had their vaccination status validly reported. 83.7% of these children had ever been vaccinated whiles the vaccination status of 1.1% was not known.

5.2 Maternal Factors

A higher proportion of the children involved in the survey had illiterate mothers, 38.1%. 36.4% of the mothers had some form of secondary education while 23.4% had some level of primary education. Only 2.1% of the mothers had post-secondary education. Also, most of the mother's were in the Agriculture sector, 41.0% while 9.5% of the mothers were not working. Only 1.7% of the mothers were professionals or managers while 39.3% were in the clerical or services sector. Most of the mothers were not malnourished, 92.6% and about 63.8% of the mothers breastfed their children for at least 18 months.

5.3 Socio-demographic Factors

The distribution of the respondents by urban and rural residence and by region is shown in Figure 5.1. The Ashanti and Northern regions are the most represented region each having 15.6% of the respondents. The least represented region is the Central region, 6.9%. It can also be seen that 66.8% of the respondents are in the rural areas while 33.2% are in urban residence. Majority of the households used borehole or well water for drinking, 48.3%. This is not surprising due to the large number of rural areas. Also, 31.5% used pipe borne water while 14.9% used natural water, such as from rivers and streams. The highest proportion of the children were in poor households, 55.2% which is almost twice as the proportion of children from rich households, 28.8%.

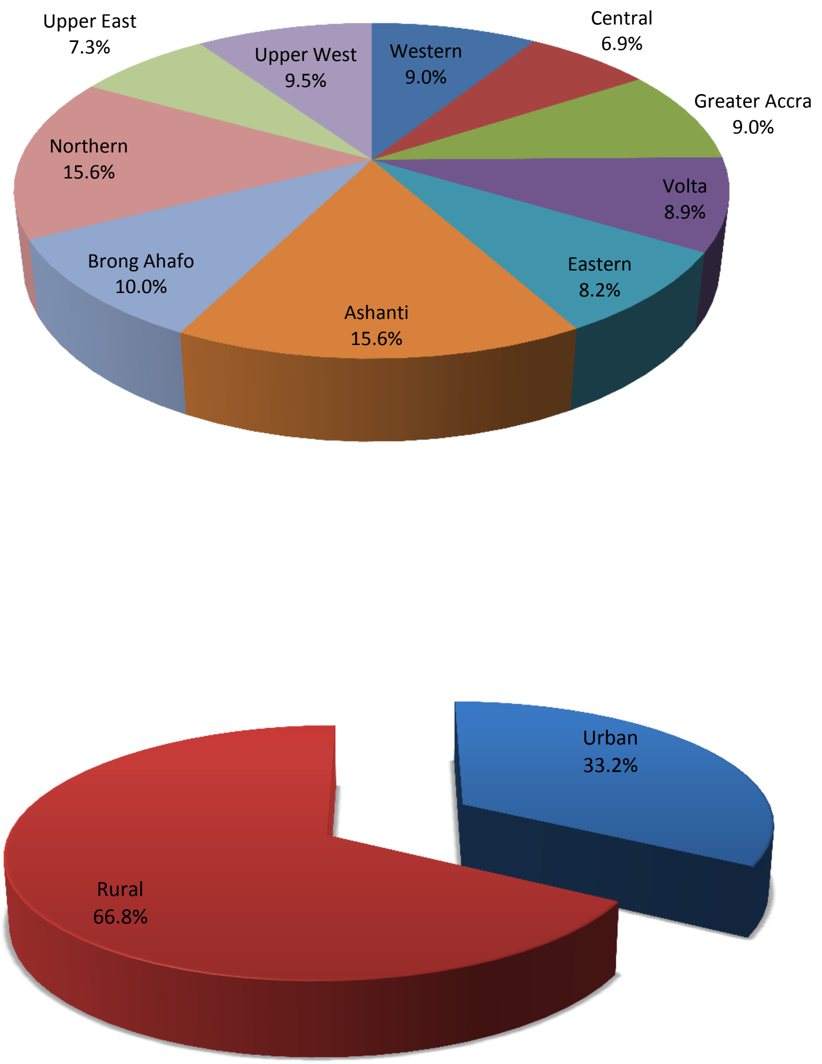

Figure 5.1: *Distribution of Respondents by Region and Residence*

5.4 Overall Prevalence of Malnutrition

The overall estimated prevalence of malnutrition as shown in Table 1 was 35.6% (33.6−37.6) which translates to approximately 1.2 million children suffering from some form of malnutrition (stunting, wasting, or under-weight). The highest prevalence was recorded among male children aged 1 to less than 2 years, 40.8% (34.4 – 47.5) and the lowest prevalence was recorded among female children who had not yet celebrated their 1st birthday 25.9% (20.5 – 32.1). As expected, the prevalence was higher in children who were older than 6 months than in children aged 6 months or less (37.1% vs. 21.4% respectively). Although the prevalence across all age groups was relatively higher in male children than in female children apart from the older children (aged 4 to less than 5 years), it was not statistically significant ($p \leq 0.1494$). Considering the regions, the Central region recorded the highest prevalence of malnutrition, 45.7% (38.9 – 52.7), followed by the Upper East region, 45.2% (35.8 – 54.8) and then the Eastern region, 43.5% (36.4 – 50.8).

Table 1: *Overall Proportion of Malnourished Children by age and sex*

Age	**Malnourished (%) 95% Confidence Interval**	**Males 95% Confidence Interval**	**Females 95% Confidence Interval**	**p-value**
Total	35.6(33.6-37.6)	37.0(34.2-39.8)	34.1(31.4-37.0)	0.1494
0≤age<1	28.9(24.9-33.2)	31.8(26.0-38.1)	25.9(20.5-32.1)	0.1620
0 – 6 months	21.4(16.5-27.1)	24.3(17.1-33.1)	18.5(12.4-26.7)	
> 6 months	37.1(30.8-43.7)	39.5(30.7-48.9)	34.4(25.7-44.2)	
1≤age<2	38.9(34.6-43.4)	40.8(34.4-47.5)	37.1(31.3-43.3)	0.4065
2≤age<3	37.0(32.5-41.7)	39.9(33.6-46.5)	33.8(27.6-40.6)	0.1820
3≤age<4	38.4(33.9-43.2)	40.5(34.1-47.1)	36.1(29.6-43.1)	0.3468
4≤age<5	34.8(30.6-39.3)	32.4(26.6-38.6)	37.4(31.2-44.1)	0.2452

*p-value shows the difference in prevalence across the gender subgroup within each category

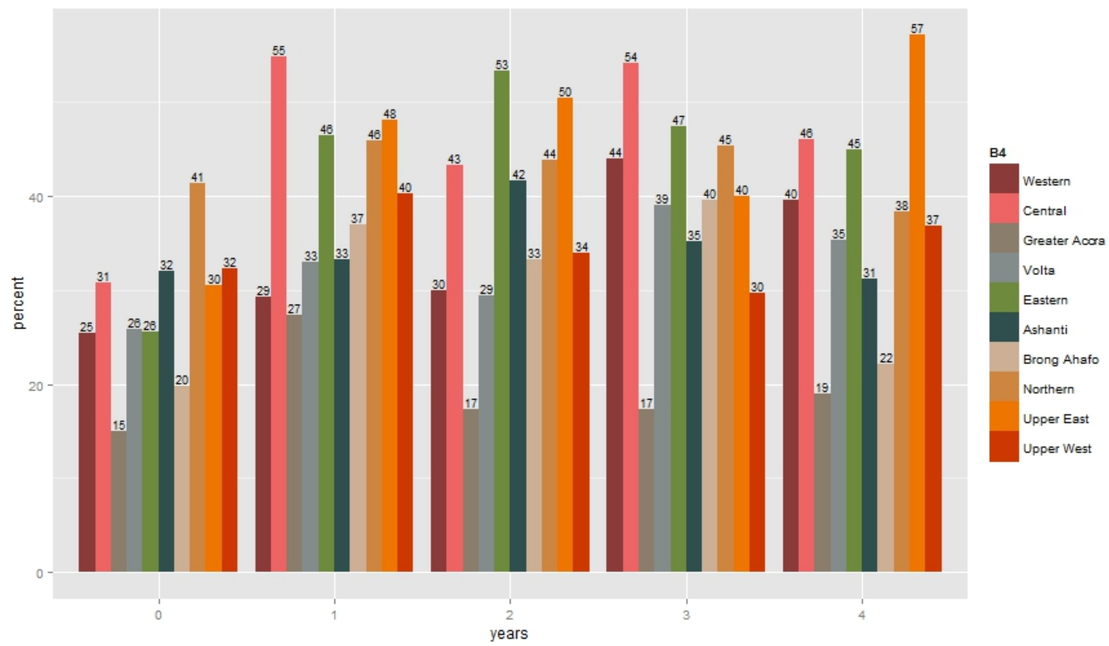

Figure 5.2: *Prevalence of Overall Malnutrition Among Children by Age and Region*

In examining the prevalence of malnutrition within the various age groups across the regions as shown in Figure 5.2, it was observed that the Northern region recorded the highest prevalence of malnutrition in children who were less than a year old, 41% $(31.0 - 52.4)$. Although high, this is relatively lower than the prevalence recorded for other age groups in other regions. The overall prevalence of malnutrition in children aged from a year old to less than 2 years was highest in the Central region, 55% $(40.7 - 68.2)$ and among the older children aged 4 years to less than 5 the highest prevalence was recorded in the Upper East region, 57% $(35.6 - 76.3)$.

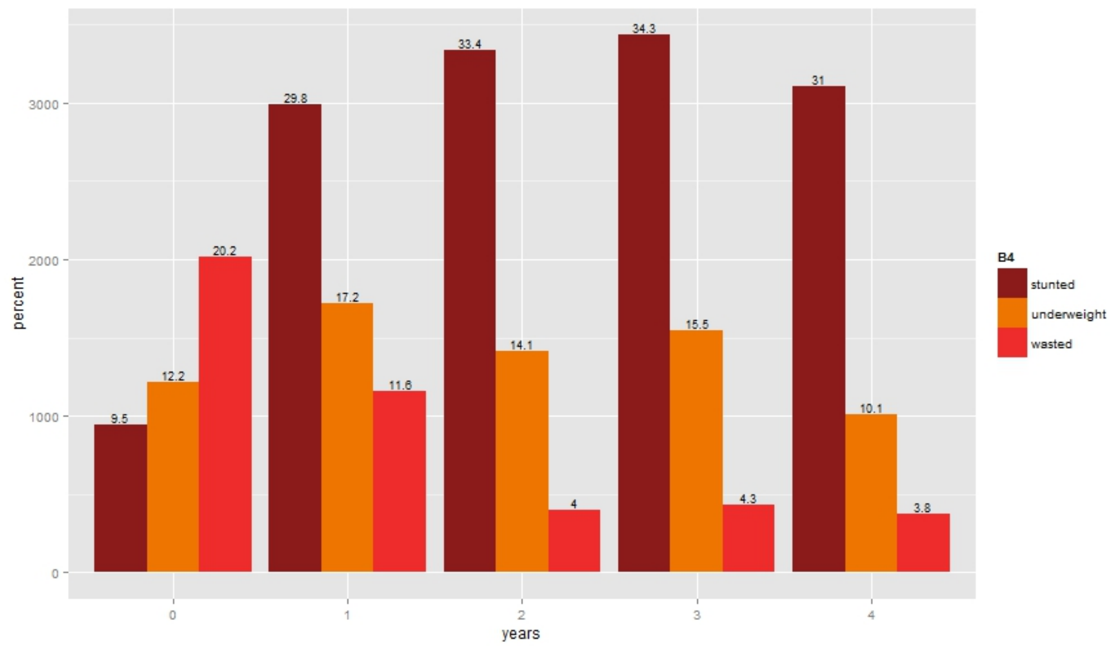

Figure 5.3: *Prevalence of Stunting, Underweight and Wasting across Age Groups*

The prevalence of stunting, wasting and underweight across age groups is seen in Figure 5.3 and Tables 1-3. The prevalence of wasting decreased significantly from 20.2% in children less than a year old to 3.8% in the older children. Whiles the prevalence of wasting decreased with increase in age, the prevalence of stunting increased from 9.5% in children less than a year old to 34.3% in children aged 3 to less than 4 years old. This however decreased to 31% in the older children. Although there was no definite trend in the prevalence of underweight ($p_{trend} \leq 0.217$), the highest prevalence was among children aged 1 to less than 2, 17.2% and the lowest was recorded in children aged 4 to less than 5 years, 10.1%. The prevalence of stunting, underweight and wasting in children is investigated by various factors that have been identified as risk factors in various literatures.

5.4.1 Prevalence of Stunting

Overall, 27.5% of children are stunted with about 9.4% being severely stunted, which means 1 in every 4 children is stunted and almost 1 out of every 10 children is severely stunted. Quite surprisingly, stunting was more prevalent among children who had ever been vaccinated, 30.9%, than among children who had never been vaccinated, 17.5%. Children who were breastfed for more than 18 months had a significantly higher prevalence than those who were breastfed for 18 months or less, 35.3% vs. 23.0% ($p \leq 0.0001$). The source of drinking water was another important factor. Children from homes that used surface water (rivers, streams, springs, or dam) and those from homes that used well/borehole water had higher prevalence, 32.8% and 30.6% respectively than children from homes that use pipe borne or mineral water, 23.3% and 17.4% respectively. Financial status also had a significant effect on stunting as the prevalence was significantly higher among children from poor homes, 33.8% than children from rich homes, and 18.1%. Similarly, examining the prevalence by educational level of the mother indicates that the prevalence is significantly higher in children whose mothers had up to primary level than in children whose mothers had form of secondary education, ($p_{trend} \leq 0.0011$). The prevalence of stunting was highest in children whose mothers were working in agriculture, 33.0% and then in children whose mothers were not working, 31.3%. The lowest prevalence were recorded in children whose mothers were in professional or managerial positions, 18.5%, and then in children whose mothers worked in clerical or other services 22.9%. The prevalence of stunting was more than ten percentage points higher in rural children, 31.9% than in urban children, 20.2% (Table 2).

Table 2: *Proportion of Stunted Children across some social and demographic groups*

Characteristic		Sample	Stunted (%) 95% Confidence Interval	p-value
TOTAL		2379	27.5(25.1-28.7)	
Age in years	0≤age<1	497	9.5(7.1-12.6)	<0.0001
	1≤age<2	511	29.8(25.9-34.1)	
	2≤age<3	459	33.4(29.1-38.0)	
	3≤age<4	432	34.3(29.9-39.0)	
	4≤age<5	480	31.0(26.9-35.4)	
Gender	Male	1193	28.9(26.4-31.6)	0.1064
	Female	1186	26.0(23.5-28.6)	
Had an Infection	Yes	994	28.9(26.1-31.9)	0.1792
	No	1379	26.4 (24.1-28.9)	
Ever Had Vaccination	Yes	441	30.9(26.7-35.5)	0.0157
	No	80	17.5(10.0-28.2)	
Duration of Breastfeeding	At least 18 months	1465	23.0(20.9-25.3)	<0.0001
	More than 18 months	833	35.3(31.9-38.8)	
Source of Drinking water	Pipe-borne	745	23.3(20.5-26.4)	<0.0001
	Mineral Water	107	17.4(11.5-25.1)	
	Well/Borehole	1141	30.6(27.8-33.6)	
	Surface/Natural	353	32.8(27.9-38.3)	
	Other Sources	17	26.3(11.4-48.6)	
Financial Status	Poor	1313	33.8(31.0-36.6)	<0.0001
	Middle Class	382	28.0(23.8-32.6)	
	Rich	684	18.1(15.5-21.0)	
Mother's Education	None	906	29.6(26.4-33.0)	0.0004
	Primary	556	31.6(27.8-35.7)	
	Secondary	864	24.3(21.6-27.1)	
	Higher	50	12.3(5.4-24.7)	
Mother is Malnourished	Yes	176	32.0(25.0-40.0)	0.1804
	No	2187	27.1(25.2-29.0)	
Mother's Occupation	Not working	226	31.3(25.4-37.8)	<0.0001
	Agriculture	970	33.0(29.8-36.3)	
	Manual	202	24.8(19.0-31.5)	
	Clerical/Services	930	22.9(20.3-25.6)	
	Professional/managerial	40	18.5(9.1-33.4)	
Locality	Urban	791	20.2(17.6-23.1)	<0.0001
	Rural	1588	31.9(29.5-34.3)	

*p-value shows the difference in prevalence across the groups within each category

5.4.2 Prevalence of Underweight

An overall underweight prevalence of 13.8% was recorded which means approximately 1 out of 7 children is underweight and 3.0% are severely underweight (Table 3). The prevalence was higher in male children, 15.5% than in female children, 12.1%. The highest prevalence was recorded in children from homes that use surface water, 16.8% and well/borehole, 16.0% and lowest in children that use Mineral water, 4.5% and other sources, 2.8%. The prevalence of underweight decreased significantly from 17.2% among children whose mothers had no education to 5.4% in children whose mothers had higher than secondary education ($p_{trend} \leq 0.0002$). Children whose mothers were underweight had a significantly higher prevalence of underweight, 21.1% than children whose mothers had normal weight, 13.2%. Similarly the prevalence was highest in children whose mothers were in Agriculture, 19.4% and in children whose mothers were not working, 16.6%. Children whose mothers were in clerical, manual or professional/managerial fields had recorded relatively lower prevalence, 10.1%, 8.1% and 5.8% respectively. Just as in the prevalence of stunting, the prevalence of underweight was significantly higher in rural children, 15.8% than in urban children, 10.5%, ($p \leq 0.0003$).The differences in prevalence of underweight children who have ever had vaccination and those who had not were not significant. Similarly, no significant difference in underweight prevalence was observed between children who were breastfed for longer than 18 months and those who were breastfed for at most 18 months.

Table 3: *Proportion of underweight children across different social and demographic subgroups*

Characteristic		Sample	Underweight (%) 95% confidence Interval	p-value
	TOTAL	2379	13.8(12.5-15.3)	
Age in years	0≤age<1	497	12.2(9.4-15.6)	0.0154
	1≤age<2	511	17.2(14.0-20.9)	
	2≤age<3	459	14.1(11.1-17.8)	
	3≤age<4	432	15.5(12.3-19.3)	
	4≤age<5	480	10.1(7.6-13.3)	
Gender	Male	1193	15.5(13.5-17.7)	0.0153
	Female	1186	12.1(10.3-14.1)	
Had an Infection	Yes	994	16.4(14.1-18.9)	0.0029
	No	1379	12.0(10.4-13.9)	
Ever Had Vaccination	Yes	441	13.2(10.3-16.8)	0.7903
	No	80	10.6(5.0-20.3)	
Duration of Breastfeeding	At least 18 months	1465	12.8(11.2-14.6)	0.0711
	More than 18 months	833	15.6(13.1-18.4)	
Source of Drinking water	Pipe-borne	745	11.9(9.9-14.4)	0.0003
	Mineral Water	107	4.5(1.8-10.0)	
	Well/Borehole	1141	16.0 (13.8-18.4)	
	Surface/Natural	353	16.8(13.1-21.5)	
	Other Sources	17	2.8(0.02-21.3)	
Financial Status	Poor	1313	18.0(15.9-20.4)	<0.0001
	Middle Class	382	12.4(9.5-16.1)	
	Rich	684	8.5(6.7-10.7)	
Mother's Education	None	906	17.2(14.7-20.2)	0.0002
	Primary	556	13.7(11.0-16.9)	
	Secondary	864	11.6(9.7-13.9)	
	Higher	50	5.4(1.4-16.1)	
Mother is Malnourished	Yes	176	21.1(15.2-28.4)	0.0050
	No	2187	13.2(11.8-14.7)	
Mother's Occupation	Not working	226	16.6(12.2-22.3)	<0.0001
	Agriculture	970	19.4(16.9-22.3)	
	Manual	202	8.1(4.8-13.0)	
	Clerical/Services	930	10.1(8.3-12.2)	
	Professional/managerial	40	5.8(1.3-18.2)	
Locality	Urban	791	10.5(8.6-12.8)	0.0003
	Rural	1588	15.8(14.0-17.8)	

*p-value shows the difference in prevalence across the groups within each category

5.4.3 Prevalence of Wasting

Wasting was diagnosed in 8.9% of the children with 2.3% severely wasted as shown in Table 4. 9.7% of the wasted children are boys whiles 8.1% are girls. The difference in prevalence was however not significant ($p = 0.1544$). Once again, there was a significant difference in the prevalence of wasting with regards to duration of breastfeeding. Children who were breastfed for at least 18 months had a higher prevalence, 11.2% than children who were breastfed for more than 18 months, 5.0%. Similarly, children from poor households were more likely to be wasted than children from rich households, 10.1% and 6.5% respectively. The highest prevalence was however recorded among children from middle class homes, 10.3% ($p_{trend} \leq 0.0097$). The prevalence of wasting had a significant trend with respect to mother's educational level ($p_{trend} \leq 0.0039$). The prevalence was highest among children whose mothers had no education, 11.5% and lowest among children whose mothers had higher than secondary education, 2.6%. Children whose mothers were underweight had a significantly higher prevalence than children whose mothers had normal weights. No significant differences in prevalence were observed among children who had ever been vaccinated and those who had not. Also the source of drinking water had no significant effect on the prevalence of wasting. Unlike in prevalence of stunting and underweight, no significant difference was observed in the prevalence of wasting between rural and urban children.

Table 4: *Proportion of wasted children across the various social and demographic subgroups*

Characteristic		Sample	Proportion Waste	p-value
TOTAL		2379	8.9(7.8-10.2)	
Age in years	0≤age<1	497	20.1(16.7-24.2)	<0.0001
	1≤age<2	511	11.5(8.9-14.8)	
	2≤age<3	459	4.0(2.5-6.4)	
	3≤age<4	432	4.3(2.7-6.8)	
	4≤age<5	480	3.8(2.3-6.0)	
Gender	Male	1193	9.7(8.1-11.6)	0.1544
	Female	1186	8.1(6.6-9.8)	
Had an Infection	Yes	994	10.1(8.4-12.3)	0.0805
	No	1379	8.0(6.7-9.7)	
Ever Had Vaccination	Yes	441	10.0(7.4-13.2)	0.7850
	No	80	9.3(4.2-18.8)	
Duration of Breastfeeding	At least 18 months	1465	11.2(9.6-12.9)	<0.0001
	More than 18 months	833	5.0(3.6-6.9)	
Source of Drinking water	Pipe-borne	745	7.0(5.4-9.1)	0.0951
	Mineral Water	107	8.4(4.5-14.9)	
	Well/Borehole	1141	9.9(8.2-12.0)	
	Surface/Natural	353	11.1(8.0-15.1)	
	Other Sources	17	2.8(0.02-21.3)	
Financial Status	Poor	1313	10.1(8.4-12.0)	0.0097
	Middle Class	382	10.3(7.7-13.8)	
	Rich	684	6.5(4.9-8.5)	
Mother's Education	None	906	11.5(9.4-14.0)	0.0039
	Primary	556	7.6(5.6-10.2)	
	Secondary	864	7.9(6.3-9.9)	
	Higher	50	2.6(0.3-12.2)	
Mother is Malnourished	Yes	176	17.0(11.7-23.9)	0.0002
	No	2187	8.3(7.2-9.6)	
Mother's Occupation	Not working	226	9.9(6.5-14.8)	0.2582
	Agriculture	970	10.1(8.1-12.3)	
	Manual	202	8.5(5.1-13.5)	
	Clerical/Services	930	8.0(6.5-9.9)	
	Professional/managerial	40	2.0(0.08-12.9)	
Locality	Urban	791	8.1(6.4-10.1)	0.2728
	Rural	1588	9.4(8.0-11.1)	

*p-value shows the difference in prevalence across the groups within each category

5.4.4 Prevalence by Locality

The prevalence in all forms of malnutrition is investigated across all ages by region and place of residence. Figure 5.4 depicts the prevalence of malnutrition by age and place of residence. In both urban and rural areas, the prevalence of stunting is much higher than the prevalence of the other two indices of malnutrition in children aged 1 and older. In the urban areas, the prevalence of stunting peaked at ages 2 to 3 years, 32.9% $(25.9 - 40.7)$ from a very low prevalence rate of 7.6% $(4.3 - 12.9)$ in children who are less than a year old. The prevalence however decreased to 15.7% $(10.7 - 22.2)$ by age 5 years. In rural areas, prevalence of stunting was much in children aged 1 to less than 5 years compared to their urban counterparts. The highest prevalence was diagnosed in children aged 3 to just about 4 years, 42.2% $(36.1 - 48.5)$, which is almost 80 percent more than the prevalence diagnosed in their urban counterparts, 23.3% $(17.5 - 30.2)$. The prevalence of stunting in the older rural children aged 4 to less than 5 years was over more than twice the prevalence that was recorded in their urban counterparts, 39.5% $(34.0 - 45.2)$ vs. 15.7% $(10.7 - 22.2)$. Similarly, the prevalence of underweight among urban children increased from 9.8% $(5.9 - 15.5)$ in children less than a year old to 13.5% $(9.1 - 19.4)$ in children aged 1 to less than 2 years. The prevalence of underweight then decreased to 6.8% $(3.7 - 12.0)$ in urban children aged 4 to less 5 years. The prevalence of underweight in rural children followed no specific trend although the prevalence was higher across all age groups in comparison with their urban counterparts. The highest prevalence of underweight in rural children was recorded in children aged 3 to less than 4 years, 20.1% $(15.5 - 25.7)$, which is more than twice the prevalence recorded in their urban counterparts, 8.9% $(5.4 - 14.3)$. The prevalence of underweight in children aged 1 to less than 2 years was also relatively high, 19.6% (15.3 – 24.6). The estimated prevalence of wasting in both urban and rural areas was highest in children aged less than a year, 17.6% (12.4 – 24.4) and 21.6% (17.2 – 26.8) respectively. Interestingly, the prevalence of wasting in children aged 2 to less than 5 years was lower in rural areas, ranging from 3.9% (2.1 – 7.1) to 3.2% (1.6 – 6.0), than in urban areas, 5.0% (2.5 – 9.6) to 4.2% (1.8 – 8.8).

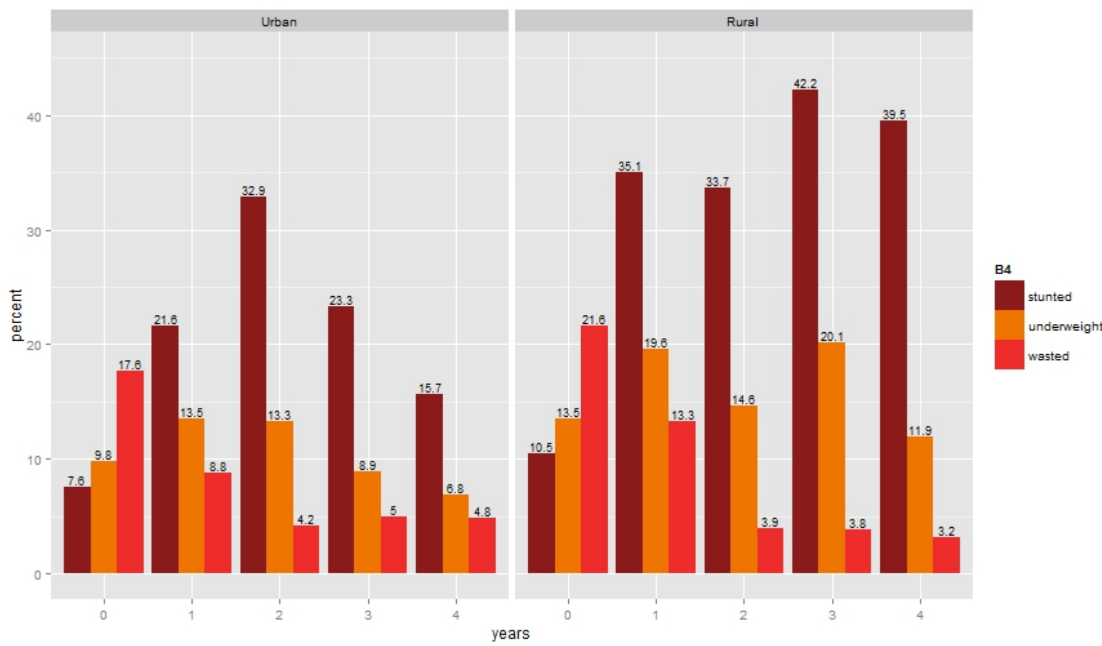

Figure 5.4: *Prevalence of Stunting, Underweight and Wasting by Age and Place of Residence*

5.4.5 Prevalence by Geographic Region

Further analysis was done to investigate the differences in prevalence of the three indices of malnutrition by age category and region of residence (Figure 5.5). As expected, the prevalence of stunting is the highest compared to the other forms of malnutrition across all the regions. The highest prevalence of stunting was recorded in the Upper East region, 36.8% $(28.0 - 46.5)$ and the second highest in the Eastern region, 36.7% $(30.0 - 44.1)$. The lowest prevalence of stunting was recorded in the Greater Accra region, 14.5% $(10.6 - 19.4)$. The highest overall prevalence of underweight was recorded in the Upper East region, 27.3% $(19.5 - 36.7)$ and the second highest in the Northern region, 20.7% $(16.7 - 25.4)$. Greater Accra region had the least prevalence of underweight children, 6.6% $(4.0 - 10.4)$. The overall prevalence of wasting in children was relatively lower across all regions. The highest prevalence of wasting was recorded in the Northern Region, 13.8% $(10.5 - 18.0)$ and the Central region, 13.3% $(9.2 - 18.8)$. The Brong Ahafo Region recorded the lowest prevalence of wasting in children less than 5 years old, 5.4% $(3.0 - 9.2)$.

Analysing the prevalence of malnutrition across the age groups within the regions shows much higher levels of prevalence as depicted in Figure 5.6. In the Upper East region, 57.0% $(35.6 - 76.3)$of children aged 4 to less than 5 years were diagnosed to be stunted. This is the highest recorded prevalence across all analysed subgroups. Also, 49.2% $(28.3 - 70.3)$ of children aged 2 to 3 years in the Upper East region were stunted and 47.1% $(30.4 - 64.4)$ of their counterparts in the Eastern region and 42.0% $(31.2 - 52.8)$ in the Ashanti region were found to be stunted. The highest recorded prevalence of underweight, 40.3% $(20.0 - 64.2)$ was among children aged 2 to less than 3 years in the Upper East region. Similarly, 29.2% $(12.3 - 53.6)$ of children aged 3 to less than 4 years in that same region and 28.0% $(17.6 - 40.9)$ in the Northern region were found to be underweight. Interestingly, in some of the regions, none of the children in some of the age groups were underweight, for instance children less than a year old in the Greater Accra region and chldren aged 3 to less than 4 years in the Eastern region. In all the regions, the prevalence of wasting was highest in

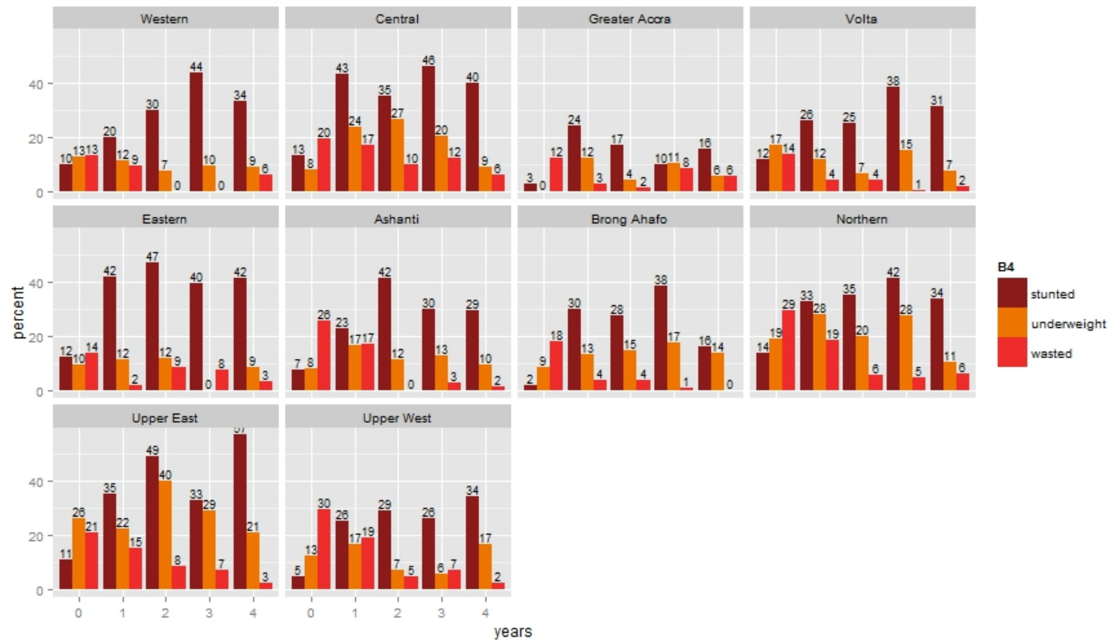

Figure 5.5: *Prevalence of Stunting, Underweight and Wasting by Age and Region*

children who were less than a year old than in older children. 30.0% (8.2 – 63.7) of children less than a year old in the Upper West region were wasted whiles 29.4% (20.4 – 40.3) of their counterparts in the Northern and 25.9% (17.0 – 37.2) in the Ashanti regions were wasted. None of the children aged between 2 to 4 years in the Western region, and those aged 2 to less than 3 years in the Ashanti region as well as children aged 4 to less than 5 years in the Brong Ahafo region were wasted. In the Upper East region, the prevalence of wasting decreased significantly from 21.2% (8.1 – 43.1) in children less than a year old to 2.6% (0.01 – 21.2) in older children aged 4 to less than 5 years.

Chapter 6

PREVALENCE OF ANEMIA AMONG UNDER-5 CHILDREN

6.1 Summary of Data

This analysis involved 2168 children aged 6-59 months of which 1073 (49.5%) were female and 1095 (50.5%) were male. The mean age in months ($\pm$ SD) was 31.6 $\pm$ 15.7 months. Although the sample was weighted, there was no significant difference between the weighted and the un-weighted estimates. The most represented age group in the analysis of anemia prevalence were children who were aged 12-23 months old, represented by the age category $1 \leq$ age< 2. This group make up 24.0% of the data while children who were 6 months but had not yet celebrated their 1st birthday were the least represented, 12.0%. Those who were 2 but not yet 3 years make up 21.4% and children aged 3 but not yet 4 make up 19.9%. The last group which makes up 22.6% of the data involved children aged 4 years but not yet 5. Also, about 32.0% of the respondents were in urban residences whiles 68.0% were in rural residences.

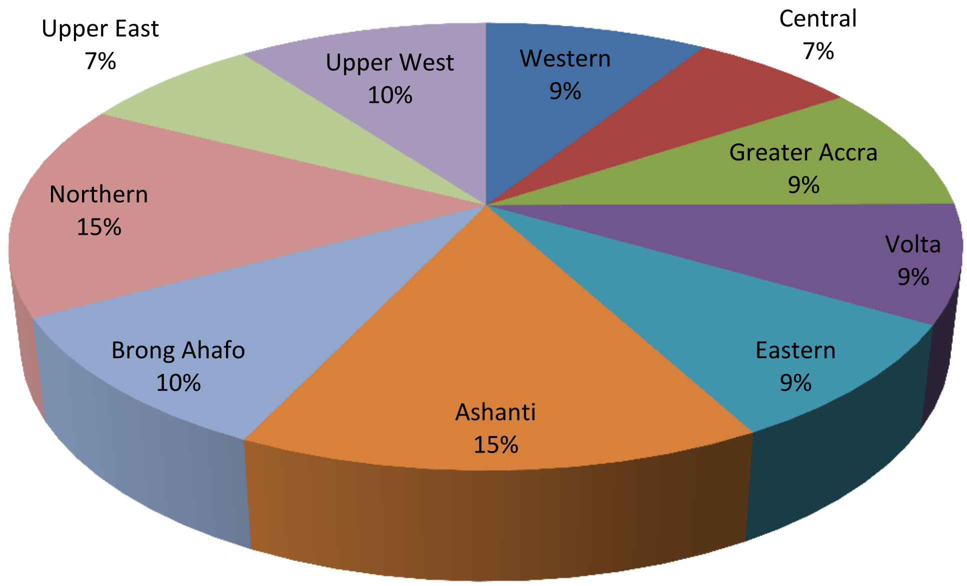

Figure 6.1: *Distribution of Respondents Across the Different Regions*

There were twice as many children from poor households (56.4%), as there were from rich households (27.7%), 15.9% of the children were from middle class households.

The sample distribution of the regions as depicted in Figure 6.1 gives the sample composition of the respondents across the regions. 15.0% of the sample is from the Northern Region and also in the Ashanti region (15.0%). Smaller percentage of the sample was from the Upper East Region (7.0%) and Central Region (7.0%).

6.2 Overall Prevalence of Anemia

The overall prevalence of anemia among children under 5 is an alarming 78.4% $(76.7 - 80.2)$ with 7.8% $(6.63 - 8.91)$ severe, 48.0% $(45.9 - 50.2)$ moderate and 22.6% $(20.8 - 24.4)$ mild. That is, over 55.0% of the children are at least moderately anemic (Hb level < 9.9g/dl). These results are consistent with the overall prevalence reported in the 2008 GDHS. In spite of this overall prevalence, heterogeneity in the data resulted in different prevalence across most categories. Table 5 represents the prevalence of anemia by some child factors and socio-economic status.

The prevalence in infants less than a year old was as high as that recorded in infants aged between 1 and 2 years old at 85.1%. The prevalence decreased consistently with age, reaching 70.5% in later years. Children who were less than 2 years old had a higher prevalence than older children (Table 5). The prevalence of anemia in male children was not significantly different from that of female children ($p = 0.167$). However, for younger children less than 2 years, the prevalence of those who were still being breastfed was significantly higher, 87.3%, $(84.4 - 89.8)$ than those who had been weaned, 74.2% $(65.4 - 81.4)$. However, in the older categories, the difference in prevalence between breastfed and weaned older children was not statistically significant ($p = 0.157$). The prevalence for children from poor households was significantly higher, 85.6% than children from rich households, 66.3%. Although the prevalence was lower in children whose birth weight was large than in those whose birth weight was small, this difference was not statistically significant ($p_{trend} = 0.2168$). The prevalence of anemia among children who had at least one co-morbidity disease was significantly higher than the prevalence among children who had no infection, 83.3% and 74.6% respectively.

Table 5: *Overall prevalence of anemia by age, gender, financial status and birth weight*

Characteristic		Sample size(n)	Prevalence of Anemia % (Weighted) (95% confidence interval)	Prevalence of Anemia % (Unweighted) (95 % confidence interval)	p- value*
	Total	2168	78·4 (76·7 - 80·2)	80·1 (78·4 - 81·8)	
Age in Years**	6 months<age< 1	260	85·2 (80·0 - 89·3)	86·5 (82·2 - 90·6)	< 0·0001
	1≤ age < 2	521	85·1 (81·6 - 88·0)	87·1 (84·2 - 90·0)	
	2≤ age < 3	465	80·0 (76·0 - 83·5)	81·1 (77·5 - 84·7)	
	3≤ age <4	432	74·0 (69·6 - 78·0)	75·5 (71·2 - 79·4)	
	4≤ age <5	490	70·5 (66·2 - 74·4)	72·2 (68·1 - 76·1)	
	< 2	781	85·1 (82·6-87·7)	86·9 (84·6- 89·3)	< 0·0001
	2≤ age <5	1387	74·8 (72·5-77·1)	76·2 (73·6 – 78·5)	
Gender	Male	1095	79·6 (77·1 - 81·9)	81·4 (78·9 - 83·6)	0·1670
	Female	1073	77·1 (74·4 - 79·6)	78·8 (76·2 - 81·2)	
Financial Status	Poor	1223	85·6 (83·3 - 87·6)	86·2 (84·2 - 88·1)	< 0·0001
	Middle	344	81·0 (76·4 - 84·6)	81·1 (76·9 - 85·2)	
	Rich	601	66·3 (62·6 - 69·8)	67·1 (63·2 - 70·8)	
Birth Weight	Large	1179	77·3 (74·8 - 79·7)	79·2 (76·9 - 81·5)	0·4530
	Normal	664	79·2 (75·9 - 82·2)	80·6 (77·6 - 83·6)	
	Small	306	80·2 (74·9 - 84·5)	81·7 (77·3 - 86·1)	
Has an infection	Yes	945	83·3 (80·7 - 85·6)	84·4 (81·9 - 86·7)	< 0·0001
	No	1219	74·6 (72·0 - 77·1)	76·7 (74·2 - 79·0)	

*p-value shows the difference in prevalence across the various groups within each category
**only children aged from 6 months to below 5 years are included in the analysis

6.2.1 Prevalence by Locality

The prevalence of anemia by age and sex, within the urban and rural populations is provided in Table 6. Overall, the prevalence of anemia for the urban population, just as was indicated in the 2008 GDHS was lower, 67.5%, than that of the general population 78.4%, and much lower than that of the rural population, 84.8%. That is, prevalence of anemia among rural children is about 17 percentage points higher than that of urban children.

The highest prevalence for the urban areas was recorded among children aged 1 year old but less than 2 years, 81.2%. This prevalence is also smaller than what is observed in the general population for the same age category, 85.1%. In the rural areas, the highest estimates were recorded in infants less than a year old, 90.1% and those aged between 1 and 2 years, 87.5%. Rural infants in these age categories had a much higher prevalence of anemia, compared to the general population, 85.1% and their urban counterparts (75.0%, 81.2%, for the two age categories, respectively). While the prevalence in the urban children decreased significantly after 2 years getting to a minimum value of 53.2% by 59 months, the prevalence in the older rural children was still relatively very high, 80.0%, which is even higher than the prevalence in urban infants. The male children in both the rural and urban areas had higher prevalence than the female counterparts, though the difference was not statistically significant ($p = 0.108$) and ($p = 0.694$), respectively.

Table 6: *Prevalence of anemia by age, sex and place of residence*

Type of residence	Characteristic	Sample size (n)	Prevalence of Anemia % (Weighted) (95% confidence interval)	Prevalence of Anemia % (Unweighted) (95% confidence interval)	p-value*
URBAN	**Total**	695	67·5 (64·3 – 70·9)	68·8 (65·3 – 72·2)	
	Age (Years)**				
	6 months<age< 1	73	75·0 (64·6 - 84·4)	75·3 (64·8 - 85·3)	< 0·0001
	1≤ age < 2	176	81·2 (75·7 - 86·9)	81·2 (75·2 - 87·0)	
	2≤ age < 3	149	69·1 (61·9 - 76·3)	69·8 (62·6 - 77·6)	
	3≤ age <4	150	61·6 (54·1 - 68·6)	62·7 (54·5 - 70·3)	
	4≤ age <5	147	53·2 (45·5 - 60·7)	55·8 (47·3 - 63·6)	
	< 2	398	79·4 (74·7-84·4)	79·5(74·5-84·6)	< 0·0001
	2≤ age <5	297	61·3 (57·0-65·5)	62·8 (58·3-67·3)	
	Sex				
	Male	350	68·2 (63·6 - 72·7)	70·0 (65·2 - 74·8)	0·694
	Female	345	66·8 (61·7 - 71·3)	67·5 (62·6 - 72·5)	
RURAL	**Total**	1473	84·8 (82·8 - 86·7)	85·4 (83·6 – 87·2)	
	Age (Years)**				
	6 months<age< 1	187	90·1 (85·5 - 94·8)	90·9 (86·7 - 95·0)	0·015
	1≤ age < 2	345	87·5 (83·6 - 91·0)	90·1 (86·9 - 93·3)	
	2≤ age < 3	316	86·2 (82·0 - 90·1)	86·4 (82·4 - 90·1)	
	3≤ age <4	282	82·6 (77·8 - 87·1)	82·3 (77·6 - 86·6)	
	4≤ age <5	343	80·0 (75·4 - 84·4)	79·3 (74·9 - 63·6)	
	< 2	848	88·4 (85·5-91·3)	90·4 (87·9 - 92·9)	0·006
	2≤ age <5	625	82·8 (80·3-85·3)	82·6 (80·1 – 85·0)	
	Sex				
	Male	745	86·3 (83·5 - 88·8)	86·7 (84·3 - 89·2)	0·108
	Female	728	83·2 (80·3 - 86·1)	84·1 (81·4 - 86·7)	

*p-value shows the difference in prevalence across the various groups within each category
**only children aged from 6 months to below 5 years are included in the analysis

6.2.2 Prevalence by Geographic Region

Of all the regions in the country, the Upper regions recorded the highest prevalence of anemia in children (Figure 6.2, Table 7). Almost 90% of children in the Upper East and Upper West regions were anemic (approximately 88.9% and 88.1% respectively). The third highest prevalence was recorded in the Central region, 85.4%, followed by the Northern region, 82.0%. The lowest prevalence was recorded in the Greater Accra region, 62.3%. Given these high prevalence within most of regions, further investigation into the prevalence among the age groups within each region shows even more disturbing rates. Over 90% of young infants in most of the regions were anemic. Specifically, the prevalence of anemia recorded in children less than a year old in the Upper West region was as high as 97.1% which is over 30 percentage points higher than the overall prevalence in Africa and 20% more than the overall national prevalence. Their counterparts in other regions such as the Northern, Western and Central regions had equally high prevalence, 91.8%, 90.3%, and 93.5% respectively. Approximately 98% or more of children aged 1-2 years in the Volta and Upper West regions had some form of anemia. Other recorded prevalence among children in this age group are 92.8% in Northern region, 92.0% in Upper East and 85.3% in Brong Ahafo region. Although the overall prevalence of anemia among older children aged 4-5 years was about 70.0%, the prevalence recorded for this age group in the regions ranged from 88.6% in the Northern region and 80.5% in the Central region to about 54.0% in the Upper East Region.

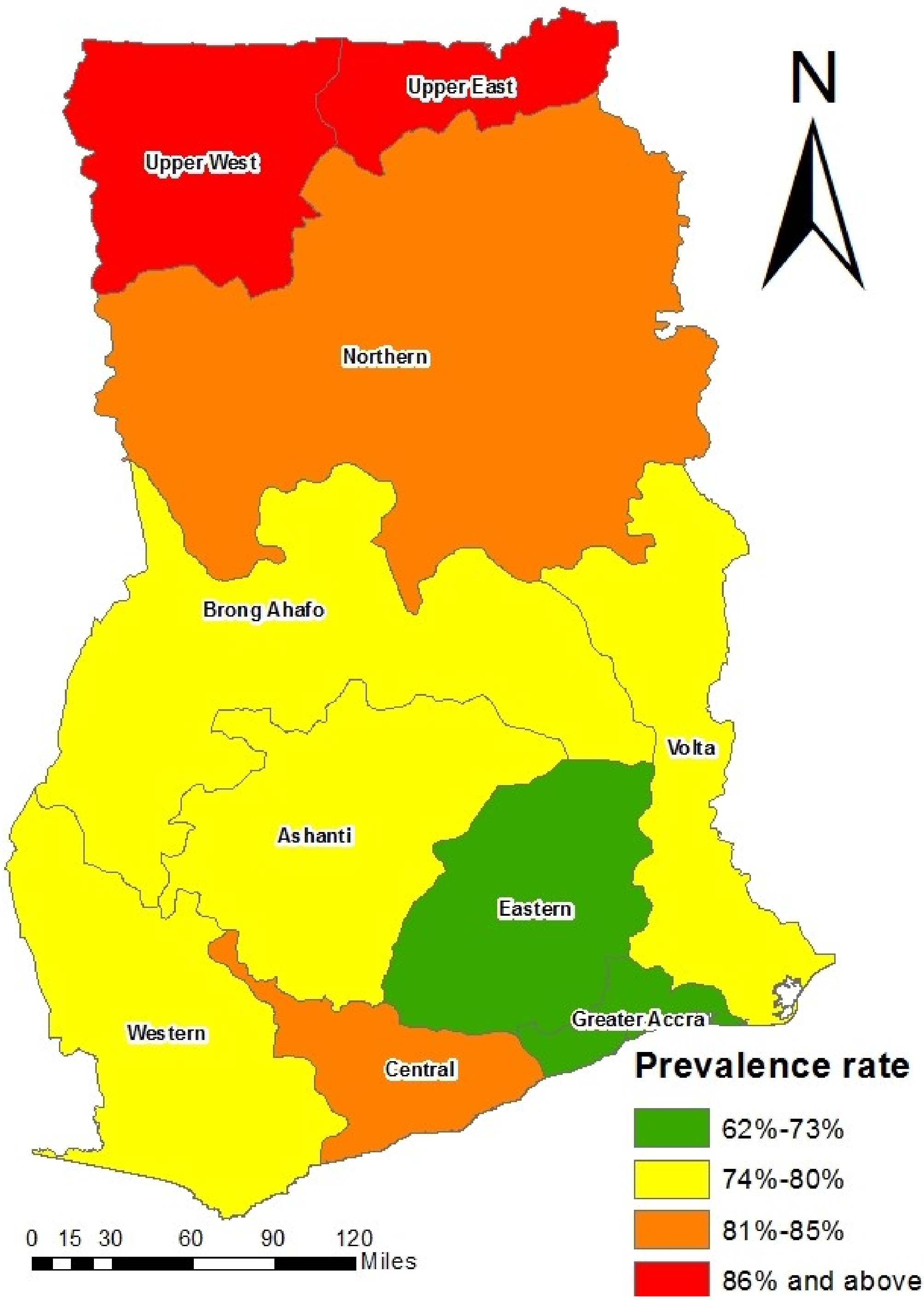

Figure 6.2: *Prevalence of Anemia by Region*

Table 7: *Prevalence of anemia by age and region*

Region Total (95% CI)	Characteristic Age (Years)	Sample size (n)	Prevalence of Anemia % (Weighted) (95% Confidence Interval)	Prevalence of Anemia % (Unweighted) (95% Confidence Interval)	p-value*
Western 79·3 (73·0-84·6)	6months<age<1	21	90·3 (70·7-98·3)	90·5 (68·2,98·3)	0·3327
	1≤age<2	46	77·1 (64·5-89·7)	80·4 (65·6-90·1)	
	2≤age<3	46	85·3 (74·8-95·8)	89·1 (75·6-95·9)	
	3≤age<4	38	69·1 (54·1-84·1)	73·7 (56·6,86·0)	
	4≤age<5	44	79·7 (67·6-91·8)	84·1 (69·3-92·8)	
Central 85·4 (79·4-90·0)	6months<age<1	17	93·5 (71·6-99·4)	94·1 (69·2-99·7)	0.2389
	1≤age<2	38	84·4 (74·3-94·6)	86·8 (71·1-95·1)	
	2≤age<3	40	88·6 (79·5-97·8)	85·0 (69·5-93·8)	
	3≤age<4	21	82·8 (68·0-97·5)	81·0 (57·4-93·7)	
	4≤age<5	30	80·5 (67·6-93·4)	80·0 (60·9-91·6)	
Greater Accra 62·3 (56·0-68·3)	6months<age<1	14	65·4 (39·8-91·0)	64·3 (35·6-86·0)	0·0252
	1≤age<2	44	79·4 (68·4-90·4)	77·3 (61·8-88·0)	
	2≤age<3	47	55·2(42·1-68·3)	55·3 (40·2-69·5)	
	3≤age<4	44	61·5 (48·3-74·7)	61·4 (45·5-75·3)	
	4≤age<5	50	54·1 (41·7-66·5)	52·0 (37·6-66·1)	
Volta 79·5 (72·8-84·9)	6months<age<1	29	81·3 (66·9-95·7)	82·8 (63·5-93·5)	0·0264
	1≤age<2	39	98·0 (85·3-99·9)	97·4 (84·9-99·9)	
	2≤age<3	36	76·6 (62·0-91·3)	75·0 (57·4-87·2)	
	3≤age<4	44	69·6 (55·6-83·7)	65·9 (50·9-79·1)	
	4≤age<5	36	73·4 (58·3-88·6)	69·4 (51·7-83·1)	
Eastern 73·4 (66·3-79·5)	6months<age<1	22	76·9 (57·3-96·5)	77·3 (54·2-91·3)	0·2160
	1≤age<2	54	75·6 (63·5-87·8)	77·8 (64·1-87·5)	
	2≤age<3	40	81·0 (67·6-94·3)	80·0 (63·9-90·4)	
	3≤age<4	32	67·1 (50·2-84·0)	68·8 (49·8-83·3)	
	4≤age<5	41	66·9 (51·7-82·1)	65·9 (49·3-79·4)	
Ashanti 79·8 (75·5-83·5)	6months<age<1	32	82·7 (70·6-94·8)	84·4 (66·5-94·1)	0.0689
	1≤age<2	80	83·1 (75·7-90·4)	83·8 (73·4-90·7)	
	2≤age<3	71	81.9 (73·6-90·2)	81·7 (70·4-89·5)	
	3≤age<4	71	80·3 (71·9-88·8)	80·3 (68·8-88·4)	
	4≤age<5	70	71·8 (62·2-81·5)	71·4 (59·2-81·3)	
Brong Ahafo 78·0 (71·9-83·2)	6months<age<1	28	88·3 (69·2-96·8)	89·3 (70·6-97·2)	0·0136
	1≤age<2	48	85·3 (74·9-95·7)	85·4 (71·6-93·5)	
	2≤age<3	48	80·4 (68·2-92·5)	83·3 (69·2-92·0)	
	3≤age<4	52	71·3 (59·1-83·5)	73·1 (58·7-84·0)	
	4≤age<5	42	70·1 (56·1-84·0)	71·4 (55·2-83·8)	
Northern 82·0 (77·2-86·0)	6months<age<1	44	91·8 (78·2-97·6)	90·9 (77·4-97·0)	< 0·0001
	1≤age<2	76	92·8 (86·6-99·1)	92·1 (83·0-96·7)	
	2≤age<3	64	87·0 (78·4-95·6)	89·1 (78·2-95·1)	
	3≤age<4	68	80·4 (70·3-90·6)	83·8 (72·5-91·3)	
	4≤age<5	83	64·8 (54·2-75·5)	68·7 (57·4-78·2)	
Upper East 88·9 (80·9-94·0)	6months<age<1	23	86·0 (55·5-97·8)	87·0 (65·3-96·6)	0·8797
	1≤age<2	32	92·0 (70·8-98·8)	90·6 (73·8-97·5)	
	2≤age<3	28	90·9 (67·1-98·7)	85·7 (66·4-95·3)	
	3≤age<4	32	86·2 (62·2-96·7)	84·3 (66·5-94·1)	
	4≤age<5	43	88·6 (70·0-96·8)	88·4 (74·1-95·6)	
Upper West 88·1(76·4-94·6)	6months<age<1	30	97·1 (52·6-100·0)	93·3 (76·5-98·8)	0·0607
	1≤age<2	64	98·7 (75·9-100·0)	98·4 (90·5-99·9)	
	2≤age<3	45	84·3 (52·7-97·3)	84·4 (69·9-93·0)	
	3≤age<4	30	78·2 (40·2-96·3)	80·0 (60·9-91·6)	
	4≤age<5	51	79·5 (49·1-94·9)	78·4 (64·3-88·2)	

*p-value shows the difference in prevalence across the various groups within each category
**only children aged from 6 months to below 5 years are included in the analysis.

6.2.3 Severity of Anemia Across Regions

The level of severity was also investigated across the regions as seen in Figure 6.3. Most of the under 5 children in all the regions had moderate levels of anemia apart from the Greater Accra region where most of the children, 50.3% $(42.3-58.3)$ had mild anemia. In the Upper East Region where the highest prevalence was recorded, 59.3% $(48.5-69.3)$ of the children were moderately anemic whiles 34.4% $(25.0-45.2)$ were mildly anemic. 6.3% $(2.5-14.0)$ of the children in this region had severe anemia. The Northern region recorded the highest prevalence of severe anemia, 15.1% $(11.1-20.2)$ whiles the Eastern region recorded the lowest, 2.8% $(0.9-7.7)$. Although the Upper East recorded the highest overall prevalence of anemia, 65.6% $(54.8-75.0)$ of the children had at least moderate anemia which is a lower prevalence than the Western region, where 78.1% $(70.7-84.1)$, Northern region, where 79.8% $(74.3-84.4)$, and the Upper West region where 84.6% $(71.4-92.6)$ of the children had at least moderate anemia.

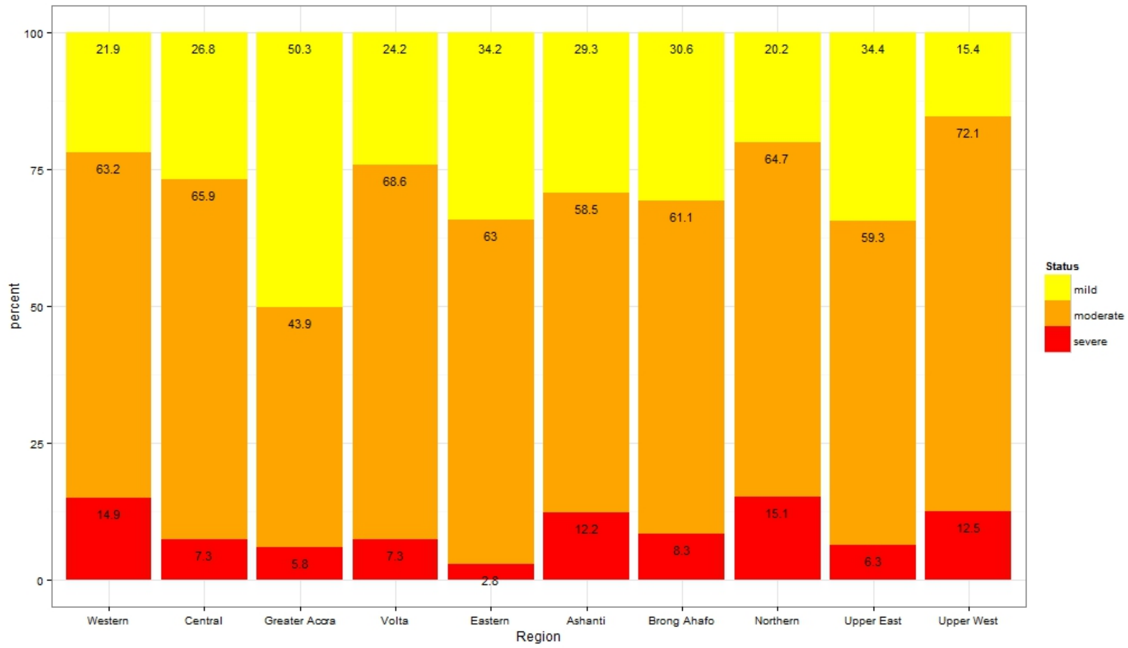

Figure 6.3: *Severity of Anemia Within the Regions*

6.2.4 Haemoglobin Concentration

The continuous haemoglobin measurements across the age categories were investigated. The overall average haemoglobin level (Hb) in children was 9.55 ± 1.83g/dl which is much lower than the WHO reference standard (11.0g/dl) for children under 5 years.

The mean haemoglobin concentration was 9.0g/dl for children aged less than one year, 9.03g/dl for those aged 1 to less than 2, 9.40g/dl for 2 to less than 3 years, 9.75g/dl for 3 to less than 4 years and 9.93g/dl for the children aged 4 to less than 5 years, which is 59 months. There was a consistent increase in haemoglobin concentration with age. The mean haemoglobin concentration for children in the rural area was 9.2g/dl compared with a concentration level of 9.9g/dl for children in the urban area. The distribution of haemoglobin concentration for the different age

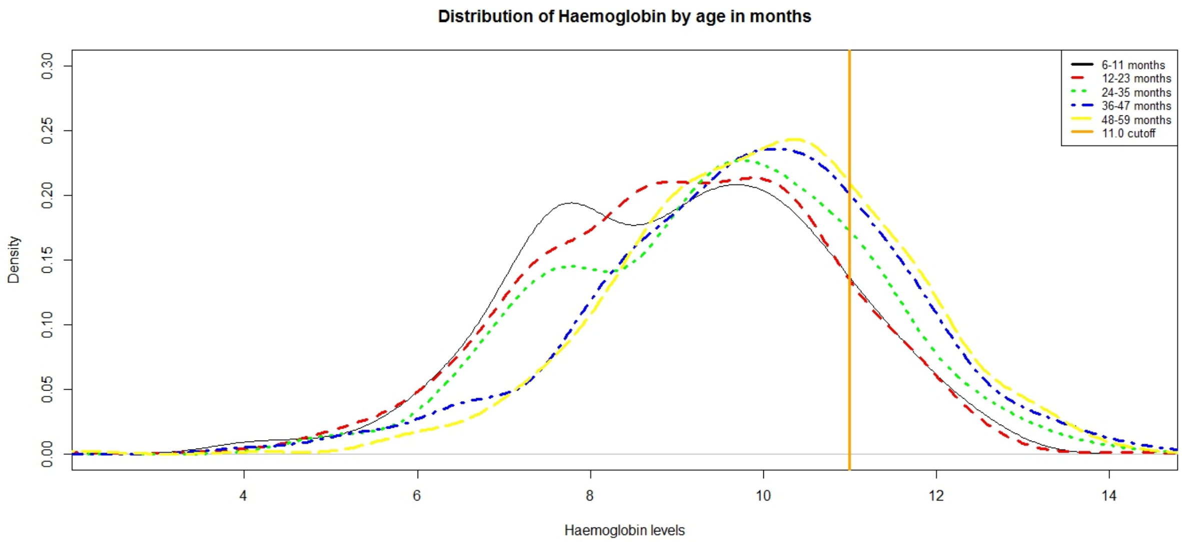

Figure 6.4: *Haemoglobin Distribution by Age Groups*

categories is shown in Figure 6.4.

Chapter 7

DISCUSSIONS AND CONCLUSIONS

7.1 Presentation and Interpretation of Results

The prevalence of all forms of malnutrition among children less than 5 years old was examined by age, region, place of residence and other socio-demographic factors that have been identified in other literature as risk factors in this study. Overall, approximately 35.6% of children suffer from some form of malnutrition (stunting, underweight or wasting). The prevalence estimates observed for stunting, 27.5%, underweight, 13.8%, wasting, 8.9%, and anemia, 78.4% are slightly different from the estimates observed in the 2008 GDHS. These differences in prevalence can be attributed to the differences in sample size and method of analysis. For this analysis, all children with missing information on height or weight measurement were discarded. Also, children with extreme measurements for height and weight which are further away from the normal range were not included. Excluding missing or flagged cases from this analysis does not affect results since the dataset is large. Also, the analysis was based on weighted data which takes care of such discrepancies.

The first aim of this study was to show the prevalence of malnutrition and anemia in children among age and gender specific subgroups as well as socio-economic subgroups. This aim was achieved by disaggregating the data into the various subgroups and examining the proportions of affected children across these subgroups. The second aim was to find out if the region and place of residence of the child had contributing explanations to the differences and this was achieved by further disaggregating the data by region and place of residence and investigating the proportions. For the third aim, the chi-square test and chi-square trend test were used to identify statistically significant associations and trends between the factors and the primary outcomes; stunting, underweight, wasting and anemia. The final aim was to make recommendations on how policy makers can use findings of the study to inform and serve as guide to improve child health. These suggestions have been discussed in detail below. As part of the analysis, sample weights were applied to obtain population representative estimates.

7.2 Discussions

The main factors that were found to be associated with all forms of malnutrition are Age, Financial status and Mother's education. This is similar to what is found in the literature (Babatunde *et al.*, 2011; Van de Poel *et al.*, 2007; Ali *et al.*, 2005; Vella *et al.*, 1992). The highest prevalence of stunting is found in the older children because stunting is the consequence of prolonged (long term) malnutrition and thus likely to be more evident in older children than in the younger ones. According to Alderman and

VK (1990), chronic malnutrition in older children is consistent with the view that low stature represents cumulative effects of nutritional shocks. The prevalence of wasting (short term malnutrition) was however higher in younger children, mostly in children aged less than a year old than in older children. The reason could be as a result of poor diet either due to infection or more importantly inappropriate feeding practices especially among children who are being introduced to complementary foods. This reason is actually manifest in the results as the incidence of malnutrition is higher in children who are older than 6 months, which is usually the period of inception of complementary feeding.

The prevalence of all three indices of malnutrition (stunting, underweight and wasting) was highest in children from poor homes than children from rich homes. This emphasizes the importance of the financial status of the household on the nutritional status of the young child. Children from poor households usually lack access to adequate nutrition, clean water and sanitation as well as effective health care. This leads to increased levels of exposure to diseases, decreased levels of resistance to infections and lower probability of receiving prompt treatment (Wagstaff *et al.*, 2004; Victora *et al.*, 2003). Poverty also leads to constraints in adequate health care both directly, such as lack of medical fees, and indirectly for instance lack of money for transportation to a health facility (Victora *et al.*, 2003). Thus children from poor households have a higher chance of suffering from malnutrition and its associated problems than children from rich homes.

The importance of mother's education on the nutritional status of the child was also established in this study. Mothers with at least secondary education were less like to have malnourished children than mothers with no education. One reason for this is that educated mothers are more knowledgeable on the right feeding practices such as the importance of exclusive breastfeeding, right time to introduce complementary feeding, as well as the right quantity, frequency, consistency and quality of food to give to the child. Secondly, educated mothers have increased awareness of health behaviour, sanitation practices and are more likely to take advantage of health care services that are available (Van de Poel *et al.*, 2007; Victora *et al.*, 2003). Lastly educational level is shown to be an indirect measure of socio-economic status (Victora *et al.*, 2003; Vella *et al.*, 1992), thus higher education leads to higher income and hence increased availability of food and nutritional resources.

The duration of breastfeeding was identified as a significant risk factor of stunting and wasting in children younger than 5 years. Children who were breastfed for at least 18 months were less likely to be stunted or wasted as compared to children who were breastfed for longer periods. This is due to the fact that production of breastfeeding is low after 12 months post-partum and hence not sufficient for the child (Vella *et al.*, 1992). Also, in a study of the feeding practices of young children, it was shown that breastfed children are less likely to consume solid foods in sufficient portions (Vella *et al.*, 1992; Brakohiapa *et al.*, 1988). In some literature, prolonged breastfeeding has been attributed to the lack of resources to provide adequate food for the child (Hong, 2007). Thus prolonged breastfeeding can be thought of as a consequence of poverty and therefore an indirect factor of malnutrition.

The source of drinking water was significant in the prevalence of stunting and underweight but not wasting. The prevalence of stunting and underweight was lower in children who were given mineral or pipe borne water than in children who were given water from boreholes, wells or natural sources such as rivers, streams or springs.

Water is an integral part of the nutrition of the child and our findings conform to what is found in other literature that access to clean water is an important risk factor of malnutrition (Babatunde *et al.*, 2011; Smith *et al.*, 2005). Access to clean water also reduces the incidence of water borne diseases and in turn decreases the risk of malnutrition due to inadequate consumption of foods.

The nutritional status of the mother was identified as a significant risk factor in the prevalence of underweight and wasting. Intergenerational effect has been identified as a reason for increased prevalence of malnutrition (Vella *et al.*, 1992). Most mothers who were malnourished in their childhood suffer from the long term effects of malnutrition and thus more likely to give birth to children with low birth weight and who are at a higher risk of being malnourished (Babatunde *et al.*, 2011; Vella *et al.*, 1992).

The difference in the prevalence of underweight between boys and girls was found to be significant. The prevalence was higher in male children than in female children. This supports studies by Van de Poel *et al.* (2007) and Hong (2007). Also, the higher prevalence of underweight and wasting in children who had an infection in the last two weeks prior to the survey was not surprising. Children suffering from any of the co-morbidity diseases have a higher probability of losing weight due to the loss of appetite leading to relatively lower consumption of food. In another vein, malnutrition in children causes an increased risk to infection and reduces their response to some pathogenic organisms in vaccines (Neumann *et al.*, 2004). A statistically significant difference in the prevalence of underweight was observed in relation to the occupation of the mother. This is also observed in studies done in the Philippines (Horton, 1986). Mother's occupation can be thought of as a consequence of mother's educational level and thus an indirect factor. It could also have a direct effect on the financial status of the mother and consequently the availability of food resources.

The higher prevalence observed in rural areas especially in the older children (as high as 42.2%) are of much concern. Although studies in countries such as Madagascar show no statistical significant differences in child malnutrition by place of residence (Fotso, 2007), the same cannot be said for Ghana. The prevalence recorded for stunting, underweight and wasting , 31.9%, 15.8% and 9.4% respectively can be attributed to; lower socio-economic status and overall living conditions which affects their food choices and feeding practices, lack of access to safe and clean drinking water and sanitation and lack of access and use of adequate health systems and facilities (Fotso, 2007; Smith *et al.*, 2005; Victora *et al.*, 2003). However the higher prevalence of wasting observed in the older urban children is of particular interest. One hypothetical reason could be that since the infant mortality rate is higher among children from rural areas than children from urban areas, (STATISTICAL SERVICE, 2012) the proportion of older children is greater in urban areas than in rural areas. Further analysis is however required to identify the main reasons behind this observed relatively higher prevalence of wasting among the older urban children.

Our analysis of the prevalence of malnutrition across the regions and then age groups within the regions showed other interesting results. Although most studies on the prevalence of malnutrition in Ghanaian children observed higher prevalence in the Northern region (Amugsi *et al.*, 2013; Alderman and VK, 1990), this studies show that other regions such as the Upper East, Central and Eastern regions have equal or even higher prevalence of malnutrition. Reasons for the high prevalence of malnutrition given in literature include ecological constraints, lack of adequate facilities, intergenerational effects and the living conditions of people in the North which is generally considered lower than found in other regions of the country (Alderman and VK, 1990). These same reasons could be attributed to the high prevalence in the Upper East region. The reason for the high prevalence observed in the Central region could be generally linked to the high level of poverty and large family sizes observed in the region (STATISTICAL SERVICE, 2012). Large family size leads to increased competition for nutritional resources and puts a burden on the food available (Amsalu and Tigabu, 2008; Van de Poel *et al.*, 2007). Poverty also leads to increased level of food insecurity and consequently increased exposure to hunger and malnutrition (Victora *et al.*, 2003).

In a similar analysis, the overall prevalence of anemia in children which is at an extremely high rate of 78.4% is a major public health concern. The alarming prevalence among infants less than 2 years of age (85.1%) and among the rural children (84.8%) is of particular concern. The higher rate among infants under 2 years would likely be due to: a) high prevalence of maternal micro-nutrient deficiency since children born to malnourished mothers have poor stores of iron, zinc, vitamin A and B12 and folate (Kotecha, 2011; Neumann *et al.*, 2004; Unicef, 2000), b) low concentration of iron in breast milk which may be insufficient to meet the daily iron requirements of the infant (Villalpando *et al.*, 2003); breastfeeding can influence the child's iron status, c) the introduction of complementary foods often occurs within this period which is also a period for rapid physical development with increased blood volume and a decrease in iron storage from maternal source (Unicef, 2000). The source of iron is now dependent on these complementary foods which are more often than not plant and cereal based (Zlotkin *et al.*, 2003; Organization *et al.*, 2000). These foods, low in energy, are also poor stores of bioavailable iron, folate, vitamin B12 and zinc since the presence of the dietary phytate in the cereals inhibits the absorption of micro-nutrients, d) the susceptibility of infants to infections and diseases which affects their nutrition and feeding and thus decreases the ability of their body to ingest and absorb iron (Osório *et al.*, 2001).

The differences in the prevalence of anemia between younger children less than 2 years old and older ones aged 2-5 years were statistically significant ($p < 0.0001$). The decline in prevalence among the older children supports similar findings in several previously reported literatures (Bernard, 2013; Villalpando *et al.*, 2003; Cornet *et al.*, 1998; Beresford *et al.*, 1971). One main reason is the decrease in iron requirements and increase in iron intakes with age (Bernard, 2013). In Ghana, mostly in rural areas, beef, eggs and other kinds of heme-containing foods (meat) are only introduced to the diet of children after weaning, which is often after 18-24 months. Also, unlike the younger children, the older children are less susceptible to infections and diseases which inhibit their iron absorption (Alonso *et al.*, 1991).

The alarming prevalence rate of anemia in the rural part of the country can also be attributed to: a) malnutrition due to limited consumption of foods rich in micronutrient as a result of poverty and less favourable socio-economic status which affects their food choices and preferences, b) lack of good drinking water and better sanitation facilities (Beresford *et al.*, 1971) leading to higher rates of infections and diseases and consequently increased risk of anemia. The results from the analysis actually confirm this hypothesis since the prevalence among children who had infections was significantly higher ($p < 0.0001$) than among children with none of the 3 infections: diarrhea, fever, and cough. c) Limited access to better and improved health care systems.

The high incidence of anemia in the country especially in the Northern parts as well as the Central region can be linked to the fact that most of the areas in these regions are rural (80.0% and above) with higher poverty rates and lower levels of education. Also, Ghana is a malaria-endemic country with intense malaria transmission in the Northern and Upper regions (Koram *et al.*, 2000). Since Plasmodium falciparum is known to be one of the leading etiological factors of childhood anemia, the results of the study is consistent with the literature (Alonso *et al.*, 1991). In the same vein, the low prevalence rate observed in the Greater Accra region could be due to the high proportion of urban areas in the region, 88.5%. However, it was interesting to find out that despite the fact that the proportion of urban areas in the Eastern is only about 32% compared to the Ashanti region with about 40% urban areas, the prevalence rate was higher in the Ashanti region than in the Eastern region. The lower prevalence in regions such as Greater Accra and Eastern could also be attributed to the interventions that have been introduced in these parts. Further research is however needed to prove that this lower prevalence is actually due to the interventions and not any other factors.

The issue of malnutrition and micro-nutrient deficiency has been given a lot of attention and the government has been committed to invest in programs and interventions that will help provide the best malnutrition (ModernGhana, 2013). Some interventions and programs that have been introduced since the the United Nations Convention on Rights of the Child and the Millennium Development Goals and even before that include Community Based Nutrition such as micro-nutrient supplementation for children aged 6 months to 5 years, Infant and Young Child feeding such as exclusive breastfeeding, promotion of appropriate complementary feeding at 6 months with continued breastfeeding until 2 years, and training on the effective prevention and treatment of diseases (ModernGhana, 2013; Ghanaian Chronicle, 2010; Ghana News Agency, 2009; Van de Poel *et al.*, 2007). Other policies that have been implemented to ensure accessible and adequate utilization of health care include cash waivers, health insurance and funds transfer (Victora *et al.*, 2003).

In spite of these and other interventions that have been in place, the prevalence observed especially in the some subgroups, for instance prevalence of stunting in children aged 4 to less than 5 years in the Upper East region, 57.0%, and the prevalence of anemia in children aged 1 to less than 2 years in the Volta region, 98.0% is evident that more improvement is needed. The minister of health in a recent address at the launch of a new baby food, Cerelac Millet, said that "Even though Ghana is largely on track to achieve most of the Millennium Development Goals (MDGs), it is unlikely that the 2015 target on MDG 4 will be met unless coverage of effective child survival interventions is increased" (Spy Ghana, 2013). In view of this call and with the evidence provided by this study, there is a need to increase efficient interventions and for the expansion of effective programs especially to specific subgroups such as those that have been identified in this study.

7.3 Recommendations

One effective way of addressing this problem is to include the differences in under 5 malnutrition between various subgroups in policies to inform resource allocation. This is because targeting regions other than socio-demographic groups increases the likelihood of missing the right population as shown by this study. Since level of mother's education and poverty have been identified as part of the core factors affecting malnutrition, another way of addressing this is for effective public education programs on child health, the dangers of anemia and appropriate feeding practices to target pregnant women and even to be introduced in formal education to reach young boys and girls even before they reach adulthood. Furthermore, education on iron-deficiency and the importance of micro-nutrients in the diet of especially children, pregnant and lactating mothers would go a long way to help solve this issue. To address the issue of poverty, there is an urgent need to see to the effective implementation and expansion of the poverty alleviation strategies and interventions that has been under way. Provision of clean water and the establishment of rules that compel households to keep a clean and healthy environment is another way to address the issue of malnutrition. In addition, nationwide broadcast on the use and drinking of treated water especially for households that do not use pipe-borne water must be encouraged. Further improvement of clinical and health care infrastructure and services such as controlling infectious diseases could also help in addressing the issue of anemia and malnutrition.

One intervention that can be used to help reduce the prevalence of anemia specifically is expanding the provision of dietary supplements rich in bioavailable iron, folate, vitamin B12 and zinc through nationwide health care programs for pregnant women, lactating mothers and children. Iron-deficiency anemia can also be prevented at a low cost with the cost-benefit ratio being recognised as one of the highest in public health (Kotecha, 2011).

7.4 Limitations and Future Work

The 2008 demographic and health survey data is secondary and therefore not specifically collected to investigate the associations analysed in this study. Hence results may have quite a lower precision than if primary data were used especially since some variables were recoded to suit the research objectives. Secondly, the use of the *months of breastfeeding* variable rather than the *duration of breastfeeding* to measure the breastfeeding practice can be criticised. Although the months recorded is the number of months they have been breastfed and not the actual number of months their mother plans to breastfeed them and thus may over represent children less than 18 months old, this variable is the most preferred in other studies (Nikoi, 2011). This is because the duration of breastfeeding variable excludes children who are still being breastfed.

Futhermore, some researchers have criticised using Body Mass Index (BMI) to measure mother's nutritional status. BMI reflects current nutritional status and therefore not relevant for kids born say, 5 years prior to interview. Also, for pregnant women BMI may not be an accurate measurement of their nutritional status (Van de Poel *et al.*, 2007). However, this study is not alone in using mother's BMI as an indirect measure of mother's nutritional status as other studies have done same (Babatunde *et al.*, 2011; Vella *et al.*, 1992).

In addition, some of the variables are based on mother's responses to questions such as whether the child had diarrhea, fever and cough in the last two weeks prior to the survey. Thus these variables are likely to suffer from recall bias as well as uncertainty about their shared meaning. Furthermore, the single cut-off haemoglobin concentration level used in defining anemia has been criticised and some researches have suggested age-specific as well as race-specific cut-offs (Brault-Dubuc *et al.*, 1983;

Owen and Yanochik-Owen, 1977).

Regardless of these limitations, the size and national representativeness of the GDHS data validates the analysis in this study. The results of this study will help inform and serve as a guide to health policies and possible interventions. It also serves as groundwork for future studies on child health in Ghana. In future research, the risk factors of malnutrition and anemia especially underlying factors influencing the prevalence in the high and also low prevalence regions as well as specific socio-demographic subgroups will be identified using standard regression models and/or multi-level modelling.

Further studies are also needed to investigate the best intervention methods that will yield positive results by reducing the problem of anemia in the Ghanaian population. In a recent survey (MICS) report, it was stated that there has been a decline in national estimates of anemia prevalence. Further studies will be needed to investigate the trends in specific socio-demographic subgroups and regions to ensure that the national estimates do not conceal deviations of the subgroups from the general trends. Finally, future research could also incorporate variables that were not analysed in this study especially those that were not available in the data.

Bibliography

African Child Policy Forum, A. (2008). African child policy forum. the african report on child wellbeing: How child friendly are african governments? addis ababa: The african child policy forum.

Alderman, H. and VK, J. E. (1990). *Nutritional Status in Ghana and its Determinants*. Number 3. World Bank Washington, DC.

Ali, S. S., Karim, N., Billoo, A. G., and Haider, S. S. (2005). Association of literacy of mothers with malnutrition among children underthree years of age in rural area of district malir, karachi. *JOURNAL-PAKISTAN MEDICAL ASSOCIATION*, **55**(12), 550.

Alkire, S. (2002). Dimensions of human development. *World development*, **30**(2), 181–205.

Alonso, P., Lindsay, S., Armstrong, J., de Francisco, A., Shenton, F., Greenwood, B., Conteh, M., Cham, K., Hill, A., David, P., *et al.* (1991). The effect of insecticide-treated bed nets on mortality of gambian children. *The Lancet*, **337**(8756), 1499–1502.

Amsalu, S. and Tigabu, Z. (2008). Risk factors for ever acute malnutrition inchildren under the age of five: a case-control study. *Ethiopian Journal of Health Development*, **22**(1), 21–25.

Amugsi, D. A., Mittelmark, M. B., and Lartey, A. (2013). An analysis of socio-demographic patterns in child malnutrition trends using ghana demographic and health survey data in the period 1993–2008. *BMC public health*, **13**(1), 960.

Anderson, A. K., Bignell, W., Winful, S., Soyiri, I., and Steiner-Asiedu, M. (2010). Risk factors for malnutrition among children 5-years and younger in the akuapim-north district in the eastern region of ghana. *Current Research Journal of Biological Sciences*, **2**(3), 183–188.

Andoh, S. Y., Umezaki, M., Nakamura, K., Kizuki, M., Takano, T., *et al.* (2007). Association of household demographic variables with child mortality in cote d'ivoire. *Journal of biosocial science*, **39**(2), 257.

Appoh, L. Y. and Krekling, S. (2005). Maternal nutritional knowledge and child nutritional status in the volta region of ghana. *Maternal & child nutrition*, **1**(2), 100–110.

Armitage, P. (1955). Tests for linear trends in proportions and frequencies. *Biometrics*, **11**(3), 375–386.

Arnold, F. and Hancioglu, A. (2010). The state of the art: DHS and MICS . `http://www.cherg.org/presentations/Arnold-Hancioglu-DHS-MICS.pptxâĂŐ`. [Online; accessed October-2013].

Babatunde, R. O., Olagunju, F. I., Fakayode, S. B., and Sola-Ojo, F. E. (2011).

Prevalence and determinants of malnutrition among under-five children of farming households in kwara state, nigeria. *Journal of Agricultural Science*, **3**(3), p173.

Benoist, B. d., McLean, E., Egll, I., Cogswell, M., *et al.* (2008). *Worldwide prevalence of anaemia 1993-2005: WHO global database on anaemia.* World Health Organization.

Beresford, C., Neale, R., and Brooks, O. (1971). Iron absorption and pyrexia. *The Lancet*, **297**(7699), 568–572.

Bernard, S. (2013). Prevalence and risk factors of anemia among children 6–59 months old in haiti. *Anemia*, **2013**.

Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., de Onis, M., and Ezzati, M. (2013). Maternal and child nutrition 1 maternal and child undernutrition and overweight in low-income and middle-income countries.

Brakohiapa, L., Bille, A., Quansah, E., Kishi, K., Yartey, J., Harrison, E., Armar, M., and Yamamoto, S. (1988). Does prolonged breastfeeding adversely affect a child's nutritional status? *The Lancet*, **332**(8608), 416–418.

Brault-Dubuc, M., Nadeau, M., and Dickie, J. (1983). Iron status of french-canadian children: a three year follow-up study. *Human nutrition. Applied nutrition*, **37**(3), 210–221.

Christofides, A., Schauer, C., and Zlotkin, S. H. (2005). Iron deficiency anemia among children: Addressing a global public health problem within a canadian context. *Paediatrics & child health*, **10**(10), 597.

Cochran, W. G. (2007). *Sampling Techniques.* John Wiley & Sons.

Cornet, M., Le Hesran, J.-Y., Fievet, N., Cot, M., Personne, P., Gounoue, R., Beyeme, M., and Deloron, P. (1998). Prevalence of and risk factors for anemia in young children in southern cameroon. *American Journal of Tropical Medicine and Hygiene*, **58**(5), 606–611.

Cusick, S. E., Mei, Z., Freedman, D. S., Looker, A. C., Ogden, C. L., Gunter, E., and Cogswell, M. E. (2008). Unexplained decline in the prevalence of anemia among us children and women between 1988–1994 and 1999–2002. *The American journal of clinical nutrition*, **88**(6), 1611–1617.

Dadhich, J. P. and Faridi, M. M. A. (2013). Maternal and child nutrition. *The Lancet*, **382**(9904), 1549.

Daniel, W. W., Cross, C. L., and Wiley, J. (1995). Biostatistics: a foundation for analysis in the health sciences.

De Onis, M. and Blössner, M. (2003). The world health organization global database on child growth and malnutrition: methodology and applications. *International Journal of Epidemiology*, **32**(4), 518–526.

DHS, M. (2006a). MEASURE DHS Data Processing. `http://www.measuredhs.com/data/Data-Processing.cfm`. [Online; accessed July-2013].

DHS, M. (2006b). MEASURE DHS Guide to DHS Statistics:Demographic and Health Surveys Methodology . `http://www.measuredhs.com/publications/publication-dhsg1-dhs-questionnaires-and-manuals.cfm`. [Online; accessed August-2013].

DHS, M. (2009). MEASURE DHS Demographic and Health Surveys 25 Years of Quality Data. http://www.measuredhs.com/Who-We-Are/upload/MEASURE_DHS_Brochure.pdf. [Online; accessed September-2013].

Ezzati, M., Lopez, A. D., Rodgers, A., and Murray, C. J. (2004). Comparative quantification of health risks. *Global and regional burden of disease attributable to selected major risk factors. Geneva: World Health Organization.*

Fleming, A. and Werblińska, B. (1982). Anaemia in childhood in the guinea savanna of nigeria. *Annals of tropical paediatrics*, **2**(4), 161–173.

Fotso, J.-C. (2007). Urban–rural differentials in child malnutrition: trends and socioeconomic correlates in sub-saharan africa. *Health & Place*, **13**(1), 205–223.

Ghana News Agency, G. (2009). Anaemia recording high prevalence rate in children and pregnant women . http://news.peacefmonline.com/health/200909/27435.php. [Online; accessed September-2013].

Ghana News Agency, G. (2012). Ghana Can Save GHc 1,658 Million if It Implements Right Malnutrition Objectives. http://www.ghananewsagency.org/health/ghana-can-save-ghc1-658-million-if-it-implements-right-malnutrition-objectives-
[Online; accessed October-2013].

Ghanaian Chronicle, T. (2010). 78% of Children in the North are Anaemic . http://thechronicle.com.gh/78-of-children-in-the-north-are-anaemic/. [Online; accessed September-2013].

Glewwe, P. (1999). Why does mother's schooling raise child health in developing countries? evidence from morocco. *Journal of human resources*, pages 124–159.

Graubard, B. I. and Korn, E. L. (1996). Modelling the sampling design in the analysis of health surveys. *Statistical Methods in Medical Research*, **5**(3), 263–281.

GSS, G. and Macro, I. (2009). Ghana demographic and health survey 2008. *Accra, Ghana: Ghana Statistical Service, Ghana Health Service, and ICF Macro*.

Hedberg, K., Shaffer, N., Davachi, F., Hightower, A., Lyamba, B., Paluku, K. M., Nguyen-Dinh, P., and Breman, J. G. (1993). Plasmodium falciparum-associated anemia in children at a large urban hospital in zaire. *The American journal of tropical medicine and hygiene*, **48**(3), 365.

Hong, R. (2007). Effect of economic inequality on chronic childhood undernutrition in ghana. *Public health nutrition*, **10**(04), 371–378.

Horton, S. (1986). Child nutrition and family size in the philippines. *Journal of Development economics*, **23**(1), 161–176.

Irwin, J. J. and Kirchner, J. T. (2001). Anemia in children. *American family physician*, **64**(8), 1379.

Janus, J. and Moerschel, S. K. (2010). Evaluation of anemia in children. *American Family Physician*, **81**(12), 1462.

Karr, M., Alperstein, G., Causer, J., Mira, M., Lammi, A., and Fett, M. J. (1996). Iron status and anaemia in preschool children in sydney. *Australian and New Zealand journal of public health*, **20**(6), 618–622.

Koram, K. A., Owusu-Agyei, S., Utz, G., Binka, F. N., Baird, J. K., Hoffman, S. L., and Nkrumah, F. K. (2000). Severe anemia in young children after high and low malaria transmission seasons in the kassena-nankana district of northern ghana. *The American journal of tropical medicine and hygiene*, **62**(6), 670–674.

Korn, E. L. and Graubard, B. I. (1995). Analysis of large health surveys: accounting for the sampling design. *Journal of the Royal Statistical Society. Series A (Statistics in Society)*, pages 263–295.

Korn, E. L. and Graubard, B. I. (2011). *Analysis of health surveys*, volume 323. John Wiley & Sons.

Kotecha, P. V. (2011). Nutritional anemia in young children with focus on asia and india. *Indian journal of community medicine: official publication of Indian Association of Preventive & Social Medicine*, **36**(1), 8.

Lakshman, R., Zhang, J., Zhang, J., Koch, F. S., and Marcus (2013). Higher maternal education is associated with favourable growth of young children in different countries. *Journal of epidemiology and community health*, **67**(7), 595–602.

Lozoff, B., Jimenez, E., and Wolf, A. W. (1991). Long-term developmental outcome of infants with iron deficiency. *New England journal of medicine*, **325**(10), 687–694.

McGillivray, M. (2007). *Human well-being: Concept and measurement*. Palgrave Macmillan.

ModernGhana (2013). Addressing Child Malnutrition in Ghana. Creating Growth and Development Opportunity for the Ghanaian Children. `http://www.modernghana.com/news/473387/1/addressing-child-malnutrition-in-ghana-creating-gr.html`. [Online; accessed October-2013].

Neumann, C. G., Gewa, C., and Bwibo, N. O. (2004). Child nutrition in developing countries. *Pediatric annals*, **33**(10), 658.

Nikoi, E. and Anthamatten, P. (2013). An examination of environmental correlates with childhood height-for-age in ghana. *Public Health Nutrition*, **16**(01), 46–53.

Nikoi, E. G. A. (2011). *Child Nutritional Well-being in Ghana: An Analysis of Associated Individual, Household, and Contextual Health Indicators and Socioeconomic and Biophysical Environmental Variables*. Ph.D. thesis, University of Minnesota.

Organization, W. H. *et al.* (2000). Malnutrition-the global picture. 2000. *World Health Organization: Geneva*.

Osei, R. D., Owusu, G. A., Asem, F. E., and Afutu-Kotey, R. L. (2009). Effects of capitation grant on education outcomes in ghana. *Accra, Institute of Social and Economic Research*.

Osório, M. M., Lira, P. I., Batista-Filho, M., and Ashworth, A. (2001). Prevalence of anemia in children 6-59 months old in the state of pernambuco, brazil. *Revista Panamericana de Salud Pública*, **10**(2), 101–107.

Owen, G. M. and Yanochik-Owen, A. (1977). Should there be a different definition of anemia in black and white children? *American journal of public health*, **67**(9), 865–866.

Potter, F. J. (1990). A study of procedures to identify and trim extreme sampling weights. In *Proceedings of the American Statistical Association, Section on Survey Research Methods*, pages 225–230.

Premji, Z., Hamisi, Y., Shiff, C., Minjas, J., Lubega, P., and Makwaya, C. (1995). Anaemia and¡ i¿ plasmodium falciparum¡/i¿ infections among young children in an holoendemic area, bagamoyo, tanzania. *Acta tropica*, **59**(1), 55–64.

Rahman, A. and Chowdhury, S. (2007). Determinants of chronic malnutrition among preschool children in bangladesh. *Journal of biosocial science*, **39**(2), 161.

Smith, L. C., Ruel, M. T., and Ndiaye, A. (2005). Why is child malnutrition lower in urban than in rural areas? evidence from 36 developing countries. *World Development*, **33**(8), 1285–1305.

Spy Ghana, S. (2013). Ghana Health Service Tackled Child Malnutrition. http://www.spyghana.com/ghana_with_collaborative_efforts_would_meet_mdg_4_target/. [Online; accessed October-2013].

STATISTICAL SERVICE, G. (2012). 2010 population and housing census.

Unicef (2000). *The State of the World's Children 2004-Girls, education and development*. Unicef.

UNICEF. (2007). *The state of the world's children 2008: Child survival*. Unicef.

UNICEF *et al.* (1993). Child malnutrition: progress toward the world summit for children goal. *New York, UNICEF*.

UNICEF *et al.* (2012). Levels and trends in child malnutrition. *UNICEF-WHO-The World Bank Joint Child Malnutrition Estimates*.

UNICEF *et al.* (2013). Improving child nutrition: The achievable imperative for global progress. *New York, NY, USA: UNICEF*, page 18.

Vaessen, M., Thiam, M., and Le, T. (2005). Chapter xxii the demographic and health surveys. *United Nations Statistical Division, United Nations Department of Economic and Social Affairs (Eds.), Household surveys in developing and transition countries. New York, NY: United Nations.*

Van de Poel, E., Hosseinpoor, A. R., Jehu-Appiah, C., Vega, J., and Speybroeck, N. (2007). Malnutrition and the disproportional burden on the poor: the case of ghana. *International journal for Equity in Health*, **6**(1), 21.

Vella, V., Tomkins, A., Borghesi, A., Migliori, G. B., Adriko, B., and Crevatin, E. (1992). Determinants of child nutrition and mortality in north-west uganda. *Bulletin of the World Health Organization*, **70**(5), 637.

Victora, C. G., Wagstaff, A., Schellenberg, J. A., Gwatkin, D., Claeson, M., and Habicht, J.-P. (2003). Applying an equity lens to child health and mortality: more of the same is not enough. *The Lancet*, **362**(9379), 233–241.

Villalpando, S., Shamah-Levy, T., Ramírez-Silva, C. I., Mejía-Rodríguez, F., and Rivera, J. A. (2003). Prevalence of anemia in children 1 to 12 years of age: results from a nationwide probabilistic survey in mexico. *salud pública de méxico*, **45**, 490–498.

Wagstaff, A., Bustreo, F., Bryce, J., and Claeson, M. (2004). Child health: reaching the poor. *American journal of public health*, **94**(5), 726–736.

Wahlqvist, M. L. and Lee, M. (2006). Nutrition in health care practice. *JOURNAL OF MEDICAL SCIENCES-TAIPEI*, **26**(5), 157.

World Food Program, W. (2008). World Food Program, Hunger Glossary. `http://www.wfp.org/hunger/glossary`. [Online; accessed 03-August-2013].

World Food Program, W. and UNICEF (2006). Ending child hunger and under-nutrition initiative: Global framework for action revised draft.

Wuehler, S. E., Hess, S. Y., and Brown, K. H. (2011). Accelerating improvements in nutritional and health status of young children in the sahel region of sub-saharan africa: review of international guidelines on infant and young child feeding and nutrition. *Maternal & Child Nutrition*, **7**(s1), 6–34.

Yansaneh, I. S. (2005). Construction and use of sample weights. *Designing Household Surveys Samples: Practical Guidelines, New York, United Nations*.

You, D., New, J., and Wardlaw, T. (2012). Levels and trends in child mortality. report 2013. estimates developed by the un inter-agency group for child mortality estimation.

Zhao, A., Zhang, Y., Peng, Y., Li, J., Yang, T., Liu, Z., Lv, Y., and Wang, P. (2012). Prevalence of anemia and its risk factors among children 6–36 months old in burma. *The American journal of tropical medicine and hygiene*, **87**(2), 306–311.

Zlotkin, S., Arthur, P., Schauer, C., Antwi, K. Y., Yeung, G., and Piekarz, A. (2003). Home-fortification with iron and zinc sprinkles or iron sprinkles alone successfully treats anemia in infants and young children. *The Journal of nutrition*, **133**(4), 1075–1080.