Child Nutritional Well-being in Ghana: An Analysis of Associated Individual, Household, and Contextual Health Indicators and Socioeconomic and Biophysical Environmental Variables

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DEDICATION

To the loving memories of my father Martin Nikoi Kotey and my mother Mary Obeng

ABSTRACT

Depriving children of the nutrients needed for growth sets them up to fail in life. When children are well nourished and cared for, they are more likely to survive, thrive, and to meaningfully contribute to society.

This study assesses the association of characteristics of individual children under age five in Ghana, their mothers, and their households—as well as socioeconomic and environmental characteristics of the places where they live—with differential nutritional well-being. What distinguishes this study from most research on young children's nutritional status in the Global South is its analysis of data for individual children, made possible by use of Demographic and Health Surveys (DHS), and assignation of district variables that capture characteristics of their places of residence to individual children as cases. This enables assessment of the relative explanatory role of variables that describe the socioeconomic and biophysical environments.

This study implements a three-level multivariate logistic regression analysis with separate models for each of the nutritional outcome variables—height-for-age, weight-for-age and hemoglobin—at each level. Descriptive statistics summarize the prevalence of stunting, underweight, and hemoglobin and delineate frequencies and proportions for selected independent variables at each level. Further statistical analysis relies on chi-squared ($\chi 2$) tests to determine significant bivariate associations. All significantly associated variables in the bivariate analysis are subjected to binary logistic regression analysis. The results of fixed effects are reported with odds ratios (ORs) along with confidence intervals for $p<.05$.

The following variables were found to be significantly associated with at least one of the three nutritional outcomes in multivariate analyses at the child and district levels: child's age, months of breastfeeding, fever, mother's health status, prenatal care, mother's occupation, mother's ethnicity, household water supply, household wealth status, population density, percent literate (vs. illiterate) in district, percent in rural (vs. urban) locations, wealth status of district residents, and ecological zone of residence. As found in much previous research, mother's education and occupation, father's education

and occupation, household size and structure, and sanitation were significantly associated with children's nutritional status in bivariate analysis but not in multivariate analysis.

After controlling for the characteristics of children, mothers and households, significant associastions with children's nutritional status were found for population density, percentage of literate (vs. illiterate) residents in a district, wealth status of district residents, and residence in the Guinea Forest-Savanna Mosaic and Central African Mangrove ecological zones. Other significantly associated variables in the final models were the age of the child, months of breastfeeding, whether the child's mother has health insurance and the wealth status of a child's household. Notwithstanding the shortcomings of this study, its findings can potentially assist stakeholders by providing a better understanding of the diverse set of factors that influence children's nutritional status and some explanation for differences in nutritional status among places within Ghana.

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INTRODUCTION AND PURPOSE OF STUDY

International donors, governments and many civil actors increasingly agree, even if only at the level of rhetoric, that tackling childhood poverty and its ramifications is of paramount importance (Bronte-Tinkew 1998; Marcus, Wilkinson, and Marshall 2002). Whether inspired by moral outrage or more instrumental arguments about the potential contribution of today's children to future economic "development" or the dire political consequences of failure to address impoverished children's plight, few overtly dispute the urgent need to improve the well-being of children.

Investing in the health of young children makes sense for a number of reasons beyond alleviation of the pain and suffering caused by even one child's death. Depriving infants and young children of basic health care and denying them the nutrients needed for growth and development sets them up to fail in life. But when children are well nourished and cared for and provided with a safe and stimulating environment, they are more likely to survive; to have fewer illnesses; and to fully develop cognitive, language, emotional and social skills. When they enter school, they are more likely to succeed. And later in life, they have a greater chance of becoming creative and productive members of society.

Investing in children is also wise from an economic perspective. According to the World Bank, immunization and vitamin A supplementation are two of the most cost-effective public health interventions. Improving vitamin A status can strengthen a child's resistance to disease and decrease the likelihood of childhood mortality. For only a small sum, a child can be protected from vitamin A deficiency and a number of infectious diseases, including diphtheria, pertussis, tetanus, polio, measles, childhood tuberculosis, and hepatitis B and Hib (*Haemophilus influenzae* type b), a major cause of pneumonia and meningitis.

Providing cotrimoxazole, a low-cost antibiotic, to HIV-positive children dramatically reduces mortality from opportunistic infections. Improvements in child health and survival can also foster more balanced population dynamics. When parents are convinced that their children will survive, they are more likely to have fewer children and provide better care to those they have —and governments can invest more in each child. Nevertheless, the processes that shape children's differential well-being and the best ways to achieve improvements remain contentious.

The 1989 United Nations Convention on the Rights of the Child (UNCRC) has been ratified by 191 governments. (Somalia and the United States are the only countries that have not ratified it.) It not only created a blueprint for child-centered policies across the globe but also provided impetus to research concerning children's well-being. Despite these welcome commitments in principle to reducing poverty and advancing other areas of human development, in practice the world hasfallen far short of meeting the convention's goals (UNDP 2003).

Child well-being should be realized through the efforts of all stakeholders concerned with children's early care and development (Pollard, Davidson, and the Center for Child Well-being 2001). Fortunately, indicators of children's well-being indicators are being adopted as indicators to monitor the need for and impact of policies and programs.

Children were paid scant attention by the discipline of geography before the "cultural turn." Prior to the recent flurry of research, Holloway and Valentine (2000, 763) observe that children were regarded as "human becomings" rather than human beings in their own right. They were often portrayed as incomplete and mostly passive, with their lives gaining meaning only in relation to adult values. Emphasis was placed on the socialization of children rather than the characteristics and experiences of the children themselves. Criticism of this focus led to emergence of a "new social studies of children" that defined the child as a "being," a social actor. The "cultural turn" in geography led to a greater appreciation of social diversity and positioned children on the research agenda for analysis as a group apart (largely from adults) and deserving attention in their own right (Matthews, Limb, and Taylor 1999). In more recent times, the importance of children to the discipline of geography has been demonstrated by the surge of interest in the everyday geographies of children and vigorous assertion for childhood space as an important dimension in social theory (Nayak 2003).

Conceptualizations of “the child” have divided most research on children into projects with global concerns and investigations of children at the local level. The former rely primarily on a social structural approach and compare the position of children in different nation-states. The latter emphasizes the socially constructed child, with great attention to particular places. Geographers can potentially combine global and local perspectives to illuminate the set of mutually constituting practices that affect children’s well-being, including their health status. The present study entails a survey of factors that shape the well-being of children under age five years in Ghana.

The Concept of Well-being

Until recently the term “well-being” was typically an appendage to “health” connected to the World Health Organization (WHO) definition of health as ”a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO 1946). Subsequently, well-being has become a central feature in the language of public health and health promotion (Morrow and Mayall 2009).

The conceptof well-being encompasses many things (Gasper 2004). For some, the term is used in the evaluation of a person’s life situation (McGillivray 2007). Others describe it as “a multidimensional construct incorporating mental/psychological, physical, and social dimensions” (Yarcheski, Scoloveno, and Mahon 1994, 288). Many more define it as “a state of successful performance throughout the life course integrating physical, cognitive, and social-emotional functions that result in productive activities deemed significant by one’s cultural community, fulfilling social relationships, and the ability to transcend moderate psychosocial and environmental problems” (Pollard, Davidson, and the Center for Child Well-being 2001, 8). Thus defined, well-being spans multiple domains and carries with it a subjective dimension in the sense of associating satisfaction with fulfilling one’s developmental potential. Additionally, this definition acknowledges such components of well-being as genetics, biology, the environment and individual experiences. More importantly, it also suggests that the expression and experience of well-being needs to be contextualized.

For a long time well-being was closely aligned to economics and assessed solely in terms of income. This reduced well-being to being well off financially or materially (McGillivray 2005). More recently, the exclusive focus on income-based measures of well-being has been found inadequate. Well-being is perhaps best summarized by the attributes identified and targeted by the Millennium Development Goals (see UNDP 2003). Other well-known multidimensional concepts of well-being include Sen's capabilities approach (Sen 1993), the intermediate needs approach (Doyal and Gough 1993), the universal human values approach (Schwartz 1994), and the domains of subjective well-being approach (Cummins 1996) among others.

The United Nations Development Program (UNDP) has created a human development index (HDI) that attempts to more adequately reflect the well-being of nations. Its goal is to create indices to meaningfully examine differences in human development over space and time. In 1996, the UNDP's measures focused on health and educational indicators (UNDP 1996). In 2006, the measures were expanded to also include income and poverty (UNDP 2006). Many scholars believe that well-being encapsulates more than income, longevity, and education, however (Alkire 2002; Fukuda-Parr and Kumar 2003; Ranis, Stewart, and Samman 2006). Missing dimensions identified by the Oxford Poverty and Human Development Initiative (OPHI), for instance, include employment of the poor, agency and empowerment, physical safety, and the ability to go about without shame (Alkire 2007). Improving well-being therefore requires not only higher levels of income, but also access to education and health services, political and civil freedom and gender equality (McGillivray 2007). Although research has come a long way in conceptualizing and measuring well-being, a lot remain to be done with respect to fine tuning indicators and measurements.

Child well-being arguably derives from the general concept of human well-being. While it is a commonly used term, it is inconsistently defined across cultures, disciplines, communities, and age groups (Pollard and Lee 2003). For some, the ability of children to successfully, resiliently, and innovatively participate in activities deemed significant by their cultural community indicates their well-being (Weisner 1998). For others, child well-being is about children's being safe, healthy and happy. It is about children's opportunities to grow and develop positive interpersonal and social relationships, feeling secure and respected as well as having a voice and being heard (African Child Policy Forum 2008). In view of the intricate and fluid nature of the concept of child well-being, its assessment should be based on a combination of child and family characteristics, including indicators of economic security, and behavior and social context as well as the ecological milieu (Federal Interagency Forum on Child and Family Statistics 2003).

Global Child Well-being

In 2009, 8.1 million children under age five died, with most deaths concentrated in low-income countries (WHO 2011b). Nearly two-thirds of these deaths were caused by preventable infectious diseases (WHO 2011a). An underlying cause of just over half of under-five deaths is under-nutrition (UNICEF 2008).

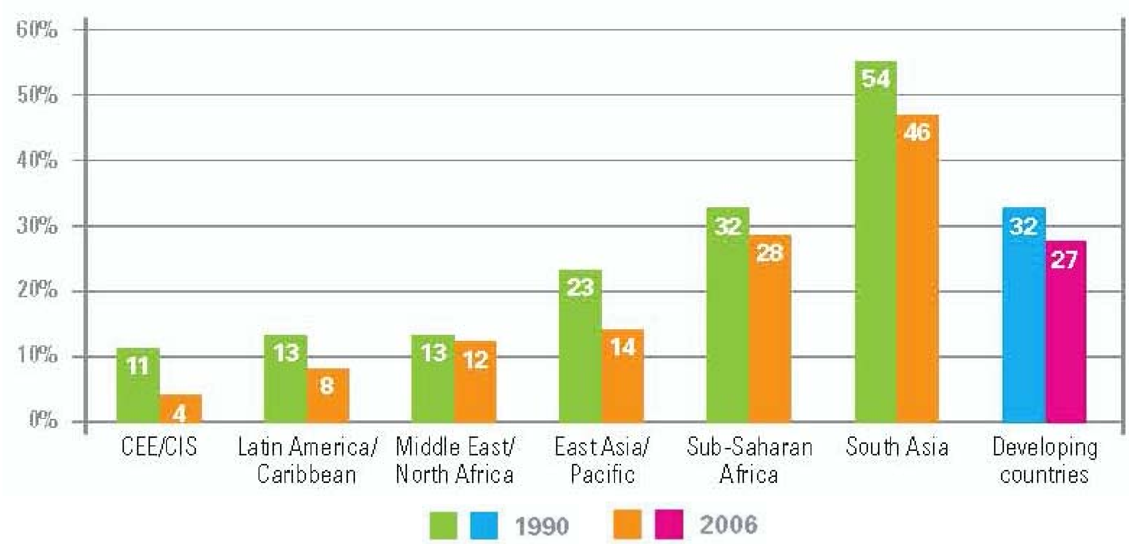
The United Nations (2005) Millennium Development Goals (MDG), adopted in 2000, proposed to halve the proportion of people living in extreme poverty between 1990 and 2015 and to insure that all children can complete a full course of primary education by 2015. Yet another goal was to reduce the prevalence of underweight among children under age five.

As of 2006, East Asia/Pacific and South Asia experienced the greatest declines in underweight (Figure 1). The Middle East/North Africa and Sub-Saharan Africa exhibited the smallest declines. Nearly three-quarters of the 62 countries that made little or no progress in child survival between 1990 and 2006 are in Africa (UNICEF 2008). Among other factors, armed conflicts and natural disasters have impeded progress.

Child Well-being in Africa

UNICEF (2008) estimates that nearly one third of children under age five in Sub-Saharan Africa are underweight. In thirteen Sub-Saharan countries, underweight prevalence rates are expected to *increase* by 2015 (Chhabra and Rokx 2004). Eastern and Southern Africa have shown no improvement in underweight in children under age five since 1990 due to a combination of declines in agricultural productivity, recurring food crises associated with drought and conflict, increased poverty, and HIV/AIDS and malaria. In five countries elsewhere in Africa (Sierra Leone, Niger, Central African Republic, Burkina Faso, and Cameroon), prevalence of underweight has not improved or has worsened (WFP and UNICEF 2006).

Figure 1: Underweight prevalence among children aged 0-59 months, 1990 and 2006



Source: UNICEF 2007

The high levels of child malnutrition in Sub-Saharan Africa reflect the region's struggling economies and high fertility. Meager resources are spread among many family members, often unevenly, in a way that increases the risk of malnutrition for the most vulnerable —children (UNICEF 2006). Furthermore, public health services are generally inadequate, and caregivers are often unable to insure that children have access to effective health services as well as food (Benson and Shekar 2006).

Only six countries in Sub-Saharan Africa (Botswana, Congo, Ghana, Guinea Bissau, Malawi, and Mauritania and Sao Tome and Principe) are expected to meet the MDG target of halving the proportion of people who suffer from hunger by 2015. These countries have increased budgetary allocations to health and education. They have increased immunization coverage and achieved nearly universal primary school enrollment (African Child Policy Forum 2008). They have demonstrated that widespread adoption of such basic health interventions as early and exclusive breastfeeding, vitamin

A supplementation, and the use of insecticide-treated mosquito nets to prevent malaria can go a long way to improve the well-being of children in Africa.

Child Well-being in Ghana

Ghana ratified the United Nations Convention on the Rights of the Child (UNCRC) in 1990 and demonstrated its commitment by launching a ten-year National Program of Action in 1992. This program translated the UNCRC document into six major Ghanaian languages, reformed laws related to children, initiated compulsory and universal basic education, and created a Ministry for Women and Children (Ampong 2005). These initiatives contributed to increased school enrollment (particularly for girls) and immunization rates. The infant mortality rate fell from 75 per 1,000 live births in 1990 to 68 in 2005 (UNICEF 2006a). The under-five mortality rate decreased from 111 per 1,000 in 2003 to 80 per 1,000 in 2008 (GSS, GHS, and ICF Macro 2009).

There is however substantially more room for improvement. About one-third of school-aged children have not yet enrolled in primary school, and children's legal rights are often violated. Between 1999 and 2006, just over one-third of Ghanaian children between five and 14 years old worked outside the home (UNICEF 2006a), many as domestic help. Widespread trafficking and sale of Ghanaian children for domestic labor and prostitution are reported (FAO 2009). One government report stated, "child protection laws are rarely invoked" (Lacroix 1997).

In 2000-2003, malaria (33%), neonatal causes (28%), pneumonia (15%) and diarrheal diseases (12%) were the main causes of death among Ghanaian children under five (UNICEF 2006; WHO 2006). In 2006, only 64% of children younger than 12 months and 73% of children age12-23 months were fully immunized, far below the goal of 90% coverage (GSS et al. 2007).

Malnutrition associated with poverty is a fundamental underlying cause of child mortality. Protein–energy malnutrition (PEM) renders children more vulnerable to morbidity and mortality (de Onis, Frongillo and Blossner 2000, UNICEF 2000). PEM is believed to be an underlying cause of approximately two-fifths of child deaths beyond infancy in Ghana (Ghana/UNICEF 2000).

Of the three anthropometric indicators of malnutrition (stunting, wasting and underweight), stunting is the most prevalent among children aged 0-4 years in Ghana. About 28% are stunted (height-for-age below 2 SD) compared to 9% wasted (weight-for-height below 2 SD) and 14% underweight (low weight-for-age). Stunting is higher among rural (32%) than urban children (21%), and children of the poor in both rural and urban areas are worse off relative to the national average (GSS, GHS, and ICF Macro 2009). UNICEF (2006a) classifies Ghana in the medium-to-high range of severity of malnutrition.

Excessive dependence on street foods probably contributes to child malnutrition and morbidity in Ghana. These foods are an important component of the diet in many low-income households (Maxwell et al. 2000). While the safety of street foods has received attention (Bhat and Waghray 2000; Garin et al. 2002; King et al. 2000), less is known about the choice and nutritional quality of street foods purchased for children. Mensah et al. (2002) report that both the type of food and serving method affect the microbial quality of food purchased, with the least contaminated being *koko,* the nutrient-poor porridge that is a common weaning food— (Colecraft et al. 2004).

The Ghana School Feeding Program (GSFP) was initiated in 2005 to improve nutrition among school-age children. A similar school feeding program initiated by the World Food Program (WFP) and Catholic Relief Service (CRS) targets girls in the Upper East and Upper West; has successfully narrowed the gap between girls' and boys' enrollment rates in these areas by linking food provision to school attendance (Adamu-Issah et al. 2007).

Informing those involved in policy and program planning and implementation in Ghana that the greatest need is in the country's North would not be useful, since that is well known. Identifying specific districts (sub-regional administrative units equivalent to counties) with specific needs, however, could be helpful in directing limited resources to appropriate target areas. Furthermore, pinpointing specific variables associated with children's nutritional status can indicate priorities for intervention and reveal patterns that merit field work to better understand the processes that produce them.

Research Objective and Questions

This study documents patterns of differential nutritional status among Ghanaian children under age five and investigates their association with demographic and socioeconomic variables at multiple levels. The analysis examines the characteristics of the places where children live—including the biophysical environment—in relation to their nutritional status.

Three related questions of both scholarly and practical significance are addressed. 1) Which characteristics of children and their mothers and households are associated with differential nutritional status? 2) After accounting for associated characteristics of children, mothers and households, do the socioeconomic and biophysical characteristics of the districts where children reside offer additional explanation for differences in children's nutritional status? 3) How might the knowledge gained in addressing the first two questions enable service providers to prioritize groups of children and the places where they live to most effectively deliver assistance? Although the data analysis is restricted to Ghana, the findings are expected to contribute to scholarship on the processes that produce observable patterns of differential nutritional status and the role of milieu in shaping children's well-being.

Rationale and Justification

Children's well-being—including their nutritional status—warrants study and intervention for countless reasons. Perhaps no other phenomenon is more central to the quality of life of adults as well as children. Many national governments lack sufficient financial resources to achieve children's rights as stipulated in the UNCRC and to achieve the U.N. Millennium Development Goals. Sadly, many apparently lack the political will to implement the measures that are financially feasible.

African children generally face higher risks and are subjected to plights more severe than children elsewhere, due to a combination of poverty, infectious diseases, and detrimental political economic realities at multiple scales. Kempe (2005) asserts that Africa is the only continent where the number and proportion of children at risk of poverty, sexual and labor exploitation, malnutrition, infectious disease, orphanhood, and mortality have been increasing over the past several decades. Sub-Saharan Africa has the world's highest child and adult mortality rates (WHO 2006).

Further research is not necessary to demonstrate that impoverished children are severely disadvantaged in quantity and quality of shelter, diet, education, and health care; are especially vulnerable to infectious diseases; and are ill equipped to contribute to a society's economic prosperity if they survive to adulthood. What is needed is research that identifies the places and groups of people with greatest need and enables us to intervene effectively to improve children's well-being.

Fortunately, data available from the Demographic and Health Surveys (DHS) since 1984 offer investigators the opportunity to explore relationships among variables related to contraception and fertility, living conditions, health status, accessibility and utilization of health services, education, household decision making, economic status, and migration. This study combines selected DHS data with information gleaned from the national census and maps of the biophysical environment.

Following this orientation chapter that introduces the study, Chapter 2 considers the relative merits of different measures of children's nutritional status, surveys what is known about the variables associated with differential nutritional status, and describes the methodology of related multivariate research. Chapter 3 addresses the data used in this study (including definition of variables) and the statistical analysis employed to assess associations between selected variables and three nutritional outcomes. Results of the analysis of characteristics of children and their mothers and households in relation to each of the nutritional outcomes are detailed in chapter 4. Chapter 5 focuses on the association of socioeconomic characteristics of the districts where children reside and their nutritional status after accounting for characteristics of children, mothers and households. In chapter 6, the significance of biophysical characteristics of the districts where children live is examined after controlling for all other variables. The final chapter summarizes the key findings and limitations of the study and discusses their implications for policies and programs. It also identifies promising directions for future research.

Chapter 2

CHILDREN'S NUTRITIONAL STATUS: MEASUREMENT AND SCHOLARSHIP

Children's well-being encompasses countless components of quality of life, incorporating such factors as political rights, economic position, opportunities, and peer relations (Ben-Arieh and Frønes 2005, 2007, 1). It is best conceptualized as a holistic and integrated state with four key domains —physical, economic, socio-emotional, and cognitive (Zaff et al. 2003). Physical well-being —including safety and security, nutrition, and health care —fundamentally reflects children's life circumstances. Physical well-being is crucial at any age but especially during the first five years of life, when children experience rapid growth and development while adjusting to their biophysical and social environments. Physical well-being during this stage of life has a lasting impact on subsequent development. Furthermore, infants and toddlers are generally more vulnerable to harm than older children.

This study focuses on the nutritional status of children under age five—arguably the requisite foundation for all other components of children's well-being. Nutritional status is linked, for example, to functioning of the immune system and cognitive development, Chapter 1 indicated that under-nutrition is an underlying cause of just over half of all deaths of children under age five worldwide. WHO estimates that it is an underlying cause of three-fifths of all under-five deaths in low-income countries (Faruque et al. 2008, Levinson and Bassett 2007). Approximately half of all deaths of children under age five occur in Sub-Saharan Africa (UN 2008).

Measurement

Direct measurement of nutritional status per se is not possible. Contemporary health care providers, international and national organizations, and researchers routinely employ four indicators to capture meaningful differences in children's nutritional status. Investigators use these as outcome (dependent) variables.

Height-for-age

In comparison to a reference population, height-for-age is generally viewed as a measure of long-term (or chronic) adequacy of consumption of nutrients, especially protein. An individual child's short stature may result from genetic characteristics, low birth weight (itself the result of complex interaction of numerous variables), and/or infectious disease but calls for further assessment of nutritional and overall health status. Disproportionately short stature for their age in a group of children within a population is usually interpreted as an indication of poor nutritional status. Most studies that use only one outcome variable for children's nutritional status use height-for-age (e.g., Fotso and Kuate-Defo 2006; Frost, Forste, and Haas 2005; Hong 2007; Hong and Mishra 2006; Van de Poel, O'Donnell, and Van Doorslaer 2007).

The length (rather than height) of a recumbent child is measured from birth to twenty-four months of age. Height of a standing child is measured beginning at twenty-four months of age. These measures are not identical, so the reference growth curves for these two age groups are discontinuous.

Weight-for-height

In comparison to a reference population, weight-for-height is understood to measure adequacy of calorie consumption. It is sometimes interpreted as a better indicator of recent (acute) consumption, in contrast to height-for-age's measurement of longer-term (chronic) consumption (Measure DHS 2010b). For both measures, a low value for an individual child may reflect expected variation within a population. By relating weight to height rather than to age, it is possible to discriminate between low body weight that is due to reduced soft tissue and due to a small skeletal frame (Keller 1991).

Weight-for-age

This is a composite index of height-for-age and weight-for-height. Because these two indices are highly correlated, interpretation of weight-for-age in a research is difficult (Heltberg 2009). For example, when the prevalence of wasting in a population is low, weight-for-age and height-for-age are similar. However, when the prevalence of wasting in a population is high, the prevalence of weight-for-age does not necessarily parallel the prevalence of height-for-age (WHO 1995). Furthermore, in contrast to height-for-age, both weight-for-height and weight-for-age may vary seasonally in undernourished populations, making the *timing* of measurement important. Taking this into account in survey research is often impractical.

Hemoglobin (Hb)

Unlike the three indicators described above, hemoglobin is less often used as an indicator of nutritional status because its measurement requires a more invasive procedure, withdrawal of a small blood sample. Iron deficiency is largely due to inadequate dietary intake of bioavailable iron[1] (Öhlund et al. 2008) or of other nutrients (e.g., calcium and protein) that affect iron's bioavailability, increased iron requirements during rapid growth periods (such as pregnancy and early childhood), and increased blood loss due to hookworm, malaria, or schistosomiasis (Greer et al. 2009). Anemia in children is associated with impaired mental and physical development and with increased morbidity and mortality. Anemia can be a particularly serious problem for pregnant women, leading to premature delivery and low birth weight. About half of the global burden of anemia is due to iron deficiency (WHO/CDC 2004). Tengco et al. (2008) provide one example of hemoglobin as the outcome variable in a study of children's nutrition. A recent research project found that dietary iron consumption and hemoglobin level in the blood may be significantly correlated during the first year of life but not the second (Öhlund et al. 2008).

In most nutrition research, height-for-age (stunting), weight-for-height (wasting), and weight-for-age (underweight) are the outcome variables, but a limited number of studies focus on hemoglobin (Olney et al. 2009). Each of these nutritional indices provides different information about child growth and body composition and hence the outcome of growth impairment (Nandy et al. 2005; WHO 1995). In survey research, Z-scores are most often used as the outcome variables' value for an individual child. These are the number of standard deviations (SD) above or below the median for the reference population. It is calculated by subtracting the reference median from the individual's measurement and then dividing that number by the reference SD (cf., Brown 2000, 7-8). A few use two or more outcome variables (Ergo, Gwatkin and Shekar 2009; Morales,

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[1] Bioavailability refers to the degree to which a substance is absorbed or becomes available at the site of physiological activity after it enters the body of a living individual.

Aguilar and Calzadilla 2004; Shin 2007; Van de Poel et al. 2008). The number of outcome variables used and how they were combined in the various studies, however, appear to have little relationship to study outcomes, which depended more on the explanatory variables used, research methodology and context of study.

Other measurements of children's nutritional status

Growth (or rather, change) in height-for-age, weight-for-height, or weight-for-age over a specific period is a sounder indicator of recent nutrition than a single measure. For example, research has indicated that slow growth in weight-for-age in children up to two years of age is a significant predictor of later slow growth in weight-for-age (Ross et al. 2009). Unfortunately, measurement of change that requires multiple measurements over time is beyond the scope of most survey research.

Body mass index (BMI) for age has been suggested as a replacement of weight-for-height as a measure of nutritional status. However, insufficient research has been conducted to compare the efficacy of these two measures (Van den Broeck, Willie, and Younger 2009). Mid-upper arm circumference (MUAC) is sometimes used in rapid field assessment of acute nutritional status to identify children eligible for supplemental feeding in emergency situations. In most populations, MUAC and height-for-age produce similar identification of severe stunting. However, in populations characterized by short trunks and long limbs, MUAC classifies fewer children as severely stunted (Myatt and Duffield 2007). MUAC identifies fewer children in all populations as moderately stunted.

Measurement of vitamin A and zinc levels in individuals are too problematic to be feasible as indicators of adequacy of those critical micronutrients (Brown 2000, 9-11). In contrast, measurement of hemoglobin—although invasive because of the requirement of a blood sample—is straightforward and practical.

Reference standards for the first three measurements

For almost three decades, the accepted reference population used internationally to assess height-for-age, weight-for-height, and weight-for-age as indicators of children's nutritional status was the NCHS/CDC/WHO growth reference. The acronyms stand for the U.S. National Center for Health Statistics, the U.S. Centers for Disease Control, and the World Health Organization. Widely accepted research has demonstrated that well-nourished young children follow similar growth patterns worldwide, at least up to seven years of age (Van de Poel et al. 2007). Environmental and economic factors, disease, and diet appear to be far more important than genetic characteristics in producing deviations from the reference. Note that reference data convey the norm, not desirable or target values (Brown 2000, 8).

Nevertheless, the NCHS/CDC/WHO reference has been criticized as inappropriate for generalization because of the ethnic homogeneity of the sample upon which it was based and the predominance of bottle feeding in the sample population. In addition, inadequate measurement of frequencies during the period of rapid growth have resulted in imprecise characterization of early infancy growth trajectories (Prost et al. 2008). In response to these criticisms, WHO conducted the Multi-Center Growth Reference Study (MGRS) between 1997 and 2003 and in 2006 released new growth standards for children from birth to sixty months of age.

The new reference is based on a sample of healthy children living under the most favorable conditions in India, Norway, Oman, the United States, Brazil and Ghana. The children in the sample were exclusively breastfed for the first six months of life; between six and twenty-four months of age, breast or bottled milk feeding was combined with solid foods according to WHO's specific IYCF (infant and young child feeding) guidelines, which include vitamin A supplementation and consumption of iodized salt (Ergo, Gwatkin and Shekar 2009). Regardless of the reference population used, all nutritional indices are expressed in standard deviation units (z-scores) from the median for the reference population (Prost et al. 2008). Z-scores based on one reference standard cannot be converted directly to z-scores for the other because they are calculated on the basis of the tails of the distribution of each population (Van den Broeck, Willie, and Younger 2009).

Several recent studies have applied both the NIHS/CDC/WHO and the new WHO reference standards to the same data sets and compared their impact on research findings. In general, use of the new growth standards classified more children as stunted for all ages from birth to sixty months and more children as wasted or underweight until six months of age (Van den Broeck, Willie, and Younger 2009). Thus far, these differences are being interpreted as the WHO standards' being "more normative and more sensitive to malnutrition" (Van den Broeck, Willie, and Younger 2009, 248).

Employing both the new standards and the old growth references in 41 low- and middle-income countries Ergo, Gwatkin and Shekar (2009) observed a 5.4 percent point increase in the prevalence of stunting with the adoption of the new standards, but the prevalence of underweight decreased in all but two of the countries, by an average of 2.9 percent. The impact of using the new standards on socioeconomic inequalities was therefore mixed. A similar study among early infants in Northern Malawi also observed prevalences 2.9-, 6.1-, and 8.5fold higher for stunting, underweight, and wasting respectively when using the WHO standards compared to the NCHS/CDC/WHO reference (Prost et al. 2008). These studies suggest that the adoption of the new WHO standards in itself is unlikely to affect policies dramatically. What may be required are different strategies in different contexts to effectively address undernutrition among children.

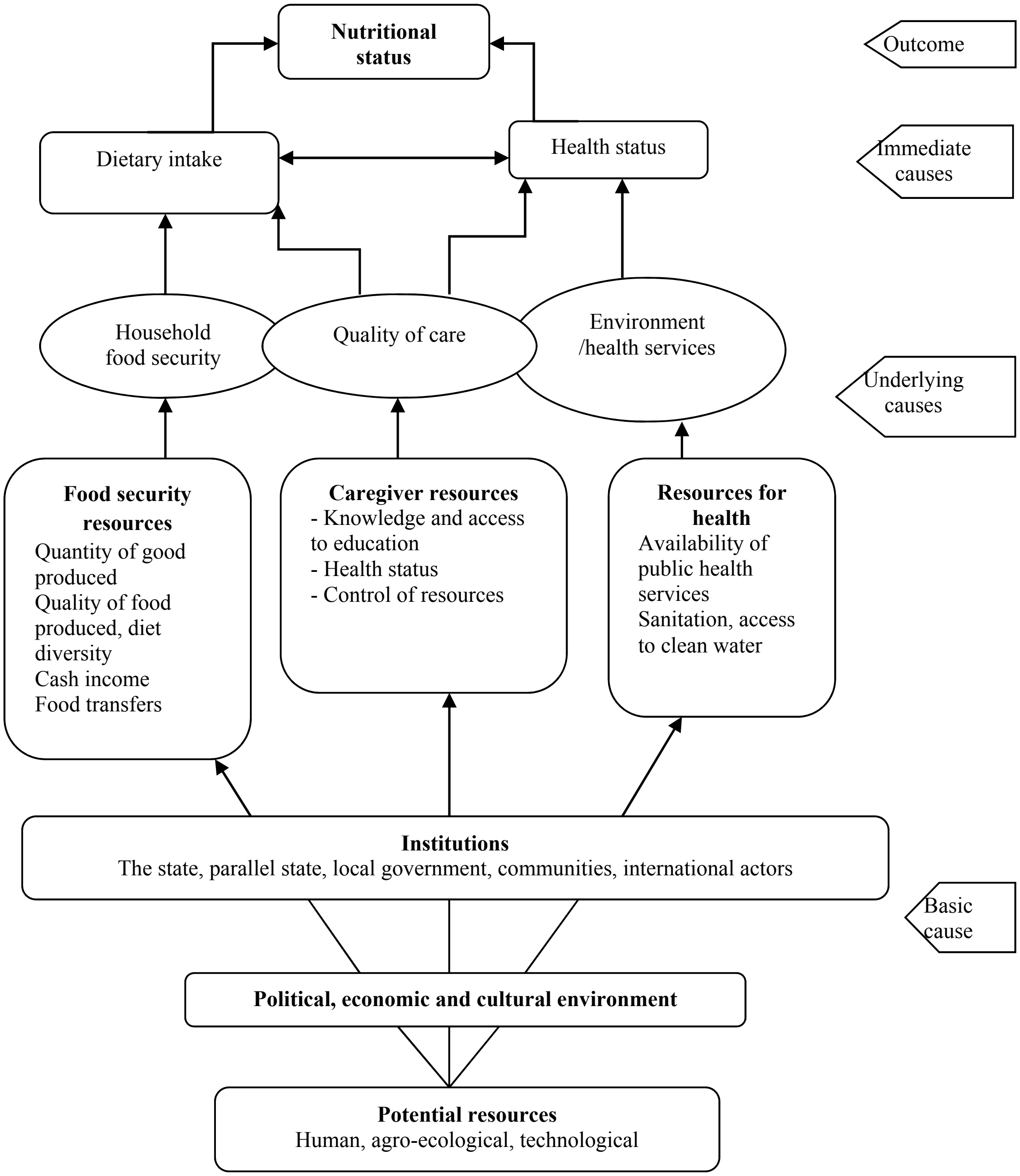
Scholarship on Associated Variables

Children's nutritional status is shaped by complex interaction of genetics, biophysical and built environments, political economy, socioeconomic status, food availability, infectious disease, health care, and culture (including care-giving practices). The following survey of existing scholarship on variables associated with children's nutritional status attempts to identify the most promising explanatory (independent) variables and the soundest methodology for enhancing understanding of the processes that produce differential nutritional status in Ghanaian children under age five.

The UNICEF model

A generalized understanding of how the nutritional status of children is related directly to dietary intake and health status of the individual child is presented by the United Nations Children's Fund malnutrition framework shown in figure 2 (Benson and Shekar 2006; Reinhard and Wijayaratne 2002).

Figure 2: The UNICEF conceptual framework of the determinants of nutritional status



Source: Benson and Shekar 2006

Diet and health status are shaped not only by the food security of the household in which a child resides, but also by the environment, the utilization of health services, and the quality of care the child receives. While none of these elements is sufficient in itself, all are necessary for satisfactory nutritional status.

A generalized understanding of how the nutritional status of children is related directly to dietary intake and health status of the individual child is presented by the United Nations Children's Fund malnutrition framework shown in figure 2 (Benson and Shekar 2006; Reinhard and Wijayaratne 2002). These are partially shaped by the food security of the household in which a child resides, the availability of health services, a healthy environment and the quality of care the child receives.

The extent to which these determinants result in the desired outcome further depends on the availability and distribution of resources. In addition to food, these resources include the physical and economic access that a child or his or her caregiver has to that food, the caregiver's knowledge of how to use available food to properly care for the child, the caregiver's own health status, and the control the caregiver has over other resources within the household (Benson and Shekar 2006).

Furthermore, children's health status is affected by the availability and quality of such resources as shelter, sanitation, water supply, health education, and preventive and curative health services.

When the distribution of resources within society is central to explaining why some are undernourished and others are not, consideration moves from the realm of the individual and household to the larger political context (Rogers and Leavitt 2003). In this realm, the UNICEF framework links the availability of resources to a set of basic determinants, which are a function of how society is organized in regard to economic structure, political and ideological expectations, and institutions through which activities are regulated and potential resources are converted into actual resources. Consequently, this conceptual framework, among other things, identifies child well-being as a subject for political debate and an issue of immediate concern to any national development strategy.

Immediate Causes

Adequate diet

An inadequate diet is one of the major causes of micronutrient deficiencies. Children whose intakes of energy and other essential nutrients reach recommended levels are considered to have an adequate diet (Ruel 2003). Chronic malnutrition arises from the interaction between inadequate dietary intakes and morbidity; it has major negative impact on children's growth and development (Dickinson et al. 2009). Although the dietary intake of a person or population cannot be the sole basis for evaluating nutritional status, it can identify an at-risk state (Faber and Wenhold 2007).

Dietary diversity has long been recognized by nutritionists as a key element of high quality diets. Increasing the variety of foods across and within food groups is recommended in most dietary guidelines because it insures adequate intake of essential nutrients and promotes good health. Recent studies in Bangladesh, Kenya and Bolivia have focused on the association between dietary diversity and health and nutritional outcomes for adults and children (Benefice et al. 2006; Hillbruner and Egan 2008; Ruel 2003).

Lack of dietary diversity is a particularly severe problem among poor populations because their diets are predominantly based on starchy staples and often include little or no animal products and few fresh fruits and vegetables (Benefice et al. 2006). These plant-based diets tend to be low in micronutrients and not easily absorbed. Thus, attempting to increase energy intake by merely providing more of the same foods without improving their diversity will not have the desired effect (Lutter and Rivera 2003). In Bolivia, where food diversity and quality were satisfactory in 54% of households but 27% had low diversity scores, growth retardation appeared during the weaning period and did not improve thereafter (Benefice et al. 2006).

Breastfeeding

Research has linked exclusive breastfeeding for the first six months of life and practices in provision of other foods to the nutritional status and survival of children under age five (e.g., Faruque et al. 2008). Besides protecting children against diarrhea, chronic malnutrition, and respiratory infections, the benefits of breastfeeding extend beyond the first year of life (Kandala, Magadi, and Madise 2006; Shapiro-Mendoza et al. 2007). Despite these benefits, evidence suggests that many mothers fail to heed the World Health Organization (WHO) recommendations for exclusive breastfeeding for the first six months and complementing breastfeeding with nutritionally adequate and safe foods thereafter (UNICEF 2007).

Breastfeeding practices and duration vary by country and culture. For instance, Gyimah (2006) observes that while breastfeeding is universal in Ghana, there are significant ethnic differences in its practice and duration. Among certain cultural groups, the newborn infant is denied the rich colostrum for the first few days because of belief that the yellowish milk is dirty and causes the infant's head to be big or ugly. Likewise, children in the Gonds and Bhills tribes in India are deprived of colostrum in the first three days of life and fed diluted honey or water instead (Bawdekar and Ladusingh 2008). In Cambodia no significant differences were observed in the prevalence of stunting among children with increased breastfeeding duration and those who were never breastfed (Hong and Mishra 2006). In a number of studies, the significance of breastfeeding for nutrition status disappeared when such factors as wealth inequalities were taken into account (Hong 2007).

Disease

In young children, dietary deficit is not the only cause of malnutrition. Infectious diseases also play an important role. Infection can suppress appetite and directly affect nutrient metabolism, leading to poor nutrient utilization. Although the effect of micronutrient deficiencies on immunity and burden of infections in developing countries is well documented, relatively little is known about the impact of infections on micronutrient status and their subsequent impact on health outcomes. All infections, irrespective of the degree of severity, decrease nutrient intakes and increase nutrient losses (Bhutta 2006). In particular, prolonged and recurrent episodes of diarrhea (including in association with HIV infection) cause morbidity and micronutrient deficiency.

In western Kenya, Bloss, Wainaina and Bailey (2004) found that except for fever and measles all illness measures were significantly associated with underweight. After controlling for vaccination and other variables in the final model, upper respiratory infection (URI) emerged as a strong predictor of underweight, while diarrhea was significantly associated with wasting. These findings suggest a close bidirectional relationship between infections and malnutrition, particularly in deprived populations, with malnutrition predisposing to infections and recurrent infections inducing and/or worsening malnutrition (Bhutta 2006).

Underlying Causes

Sex

Although Hong and Mishra (2006) found only slight sex differentials in the prevalence of stunting in Cambodia and Cameron and Lim (2007) found no significant difference in any nutritional outcomes between boys and girls in Northeast Thailand, overwhelming evidence seems to point to male children's being nutritionally disadvantaged in most low-income countries. Marcoux (2002, 280) notes, "The statistical evidence tells us that, where detectable differences by sex exist, boys usually fare worse than girls by anthropometric indicators."

Several other studies in low-income countries, most of them in Sub-Saharan Africa, confirm that male children are more likely to be stunted than their female counterparts (Hong and Mishra 2006; Hong 2007; Morales, Aguilar and Calzadilla 2004; Van de Poel et al. 2007; Wamani et al. 2007). Mishra, Roy, and Retherford (2004) found no evidence of universal discrimination in childhood feeding and nutritional status against girls in India, and noted that sex differentials in nutrition depended more on birth order and the sex composition of older living siblings. In Ghana, male children were found to be more prone to malnutrition than their female peers (Hong 2007; Van de Poel et al. 2007). Nevertheless, a large number of studies indicate strong preference for sons in many developing countries for economic, social, and religious reasons (Mishra, Roy, and Retherford 2004).

Age

Several surveys have reported a significant relationship between the age of a child and nutritional outcomes. These studies reveal that across the board, only minimal deviation from normal stature and weight growth patterns are observable before age 12 months, and that growth deficits accelerate rapidly afterwards (Bloss, Wainaina and Bailey 2004; Hong 2007; Marins and Almeida 2002; Wamani et al. 2006). Studying poor nutritional health among Bedouin preschool children in Jordan, Khatib and Elmadfa (2009) observed that growth deficits in children developed slowly during late infancy. In Brazil, a study by Marins and Almeida (2002) found that the most critical age ranges for under-nutrition risk were 13-24 and 25-36 months.

In a different context in rural Uganda, Wamani et al. (2006) found among children under two years of age that while 30% were already stunted at nine months of age, by 18 months up to 50% were stunted. The highest proportion of wasting (7%) was also observed in the 12- to 17-month age group, while underweight and stunting continued to increase among children aged 18–23 months. In Kenya, children in the age group 13–24 months had the highest prevalence of underweight, stunting, and wasting when compared with other age groups (Bloss, Wainaina and Bailey 2004). After controlling for other variables in the model, children aged 13–24 months were approximately three and four times more likely to be underweight and stunted, respectively, than children in the 0–12 month age group.

These findings confirm what is known about the risks associated with weaning to an adult diet. As children become more mobile and independent, they may consume less sanitary food and otherwise have greater exposure to infectious disease agents. They may consume foods that are not easily digested. Weaning practices affect the foods that toddlers eat, how they are prepared and stored, dietary diversity, and other factors that have a direct influence on nutritional and infectious disease status.

Birth weight

The well-established effect of low birth weight on child health and nutrition makes it the single factor most relevant for children’s survival (El Taguri et al. 2009). In a Brazilian study, Marins and Almeida (2002) found that children whose weight was low at birth were at greater risk of under-nutrition even after age 13 months. Another study in Libya concluded from multivariate analysis that birth weight was strongly correlated with stunting (El Taguri et al. 2009).

Hong (2007) observed in Ghana that even with household economic status and other factors controlled; birth weight was significantly associated with stunting. In a different study that examined the effect of maternal HIV status on child survival in Ghana, Hong, Banta and Kamau (2007) found, after controlling for other factors, that children with normal birth weight were significantly less likely to die in infancy than children with low birth weightIn sum, children's birth weight deficits affect their growth for years.

Wealth

Financial status obviously affects household and individual access to food. Poverty is therefore an important correlate of child nutritional outcome and has been heavily investigated (Assis et al. 2007; Heltberg 2009; Hong 2007; Hong and Mishra 2006). Since economic growth does not benefit all groups within a society equally, economic inequality must be taken into account. Economic well-being at the household level affects the health and nutritional status of children through access to better food, more hygienic living conditions, and better access to health services (Hong and Mishra 2006).

Poor children commonly suffer disproportionately from almost every disease and nutritional deficiency and show higher rates of mortality than their more prosperous counterparts (Seccombe 2000). Conversely, higher family income enables parental investment in health promotion that leads to better outcomes in children's well-being (Iceland 2005). Poverty is, however, more than the lack of income or assets because it encompasses the opportunities or lack thereof that households have to achieve positive outcomes in child well-being (Haddad et al. 2003).

In Ghana, Hong (2007) found that-independent of the characteristics of children and their mothers and households, children in the poorest 60% of households had more than double the risk of being stunted compared with children in the richest 20% of households. Hong and Mishra (2006) found a similarly strong association in Cambodia. Although these studies can be criticized for the cross-sectional nature of the data used and for suggesting a perhaps overly simplistic causal relationship between household economic status and children's nutritional status, they nonetheless imply that reducing economic inequalities and making services more accessible to the poor are keys to improving children's health and nutritional well-being.

The mounting evidence of childhood poverty as a strong predictor of adult poverty (Marcus, Wilkinson, and Marshall 2002) should nevertheless be interpreted cautiously because childhood poverty does not necessarily lead to adult poverty. Childhood poverty can—at least sometimes and partially—be resisted or reversed, both during childhood and adulthood, if conditions improve (Yaqub 2002).

Sociocultural variables at the household and individual level

In addition to wealth, a number of studies have found a relationship between household structure and economic resources, on the one hand, and child nutritional outcomes, on the other (Andoh et al. 2007; Bindon and Vitzthum 2002; Bronte-Tinkew and DeJong 2004; Cameron and Lim 2007). Bronte-Tinkew and DeJong (2004) found in Jamaica that children in low-income and/or single-parent and cohabiting households are more likely to be stunted. Cameron and Lim (2007) arrived at a similar conclusion in Thailand. They found that compared to nuclear families, children in households with other structures have significantly worse nutritional outcomes.

Gyimah (2009) reports that polygamy accounts for one-fifth to half of Ghanaian marriages. This distinctive household structure is important because it has unique implications for the health and survival of children in Africa. Overall, polygamous households produce more offspring than monogamous ones. Low paternal investment in these households combined with the tendency for selective allocation of resources (favoring some wives over others) means that children in these households may have fewer resources for everything from food to health services, and are therefore exposed to a higher risk of death than their counterparts in monogamous households.

In many African cultures, the male ‘‘head” enjoys the highest status in the household (Gage 1997). He has decision-making authority, is financially responsible for the household, and is often the most respected person. Thus, the means of production in the form of land and cattle as well as cash income from agriculture and other activities are largely controlled by men. Women’s relationship to the means of production is determined primarily by their relationship to men. With marital dissolution rates of 24-60% for first marriages, many women have little access to resources necessary for their children’s physical growth and development. Although Gage (1997) found no difference in nourishment between Kenyan children from polygamous households and those from other household types, she found that children of never married and formerly married mothers were significantly less likely to complete recommended series of vaccinations and exhibited higher rates of acute malnutrition. Among children whose mothers had previously been married, the number of male household members of working age greatly enhanced children’s chances of full immunization and normal nutritional status.

Likewise, Leroy, Razak and Habicht (2008) found in northern Ghana that children of household heads were taller than those of other males and that the children of first wives, who by definition have better access to the head, were taller than those of second wives. They also found that polygamy was associated with lower rates of full immunization for polio and other infectious diseases.

Mother’s age at child’s birth

Very young mothers are often at a disadvantage because of their physiological immaturity and limited capacity to handle the social and psychological stress that comes with child bearing at a young age. For instance, the youngest mothers (age twenty and under) in Nigeria were less knowledgeable about growth monitoring and promotion and ORT (oral rehydration theory) than older mothers (Sanusi and Gbadamosi 2009), and in Malawi the prevalence of fever and diarrhea in young children was lower for those with mothers ages 22-35 years and 35-49 years compared with those younger than 22 years (Kazembe, Muula and Simoonga 2009). In urban Brazil, Santo, de Oliveira, and Giugliani (2007) noted that adolescent mothers (those age twenty and under) were less likely than older mothers to follow the WHO recommendation of exclusive breastfeeding of infants until six months of age, and Spinelli et al. (2005) found that 6- to 12-month-old infants of adolescent mothers were significantly more likely to be anemic. However, in the Philippines, Bondy et al. (2009) found in bivariate analysis that maternal age was not a statistically significant predictor of full immunization status. Notwithstanding this finding, most research indicates that young mothers are less likely to have children with positive health and nutrition measures.

Mother's nutritional status

A number of studies have found an association between the nutritional status of mothers, especially during pregnancy, and both short- and long-term health and nutrition indicators for their children in both developed and developing countries (see Janjua et al. 2009, Ohlund et al. 2008, Rahman and Chowdhury 2007, Singh et al. 2009). In general, poorly nourished mothers were more likely to give birth to low-weight infants and to have malnourished children. In urban Pakistan, mothers who had low dietary intake of vitamin C and poor nutritional status as measured by below-median mid upper-arm circumference (MUAC) and biceps skinfold thickness (BSFT) were more likely to give birth to infants with low weight (Janjua et al. 2009). In Sweden, the hemoglobin of children was significantly associated with their mothers' hemoglobin (Ohlund et al. 2008).

Medhin et al. (2010) found with both logistic and linear regression models that prenatal maternal nutritional status (as well as male gender, low birth weight, and lack of sanitary waste disposal) was significantly associated with under-nutrition in infants at ages six and twelve months in rural Ethiopia. Moreover, Singh et al. (2009) found in Nepal that mother's BMI (calculated from weight and height) was strongly associated with underweight children in bivariate analyses and to both underweight and stunting in multiple logistic regression analyses.

These findings suggest that properly nourishing mothers would be likely to produce positive nutritional outcomes in their children in both the short and long term. Efforts to improve children's nutritional status should take this into account.

Mother's health status (HIV/AIDS)

The HIV epidemic in many developing countries, particularly in Sub-Saharan Africa, has undermined gains in child survival in recent decades (Hong, Banta and Kamau 2007; Mishra et al. 2007; Saloojee et al. 2007). HIV infection in mothers affects child survival through vertical transmission of the virus to children and results in premature births and low birth weight (Hong, Banta and Kamau 2007). Children born to HIV-infected mothers are at high risk of becoming HIV positive if they are not treated. Furthermore, the earnings of most HIV-infected mothers whose disease is not effectively treated decline, and their limited resources are likely to be diverted to their own medical care. Economic inactivity coupled with social stigmatization (Chiao, Mishra, and Sambisa 2009) mean that children of mothers living with HIV/AIDS face bleak prospects for obtaining proper care and adequate food.

In a six-country study in Southern Africa (in Lesotho, Malawi, Mozambique, Swaziland, Zambia and Zimbabwe), Mason et al. (2005) examined the synergistic relationship among AIDS, drought and child malnutrition and found that areas with higher HIV/AIDS experienced greater decline in child nutrition. They concluded among other things that HIV/AIDS amplifies the effect of other risk factors on nutrition. A similar result was found in a case-control study of severe childhood malnutrition in South Africa. A multivariate analysis showed that risk factors for severe malnutrition included suspicion of HIV infection of parents or children in a family (Saloojee et al. 2007). In Kenya, children of HIV-infected parents were more likely to be underweight and wasted, and less likely to receive medical care for ARI and diarrhea (Mishra et al. 2007). In Ghana, children born to HIV infected mothers are 3.5 times as likely to die during infancy as those born to uninfected mothers (Hong, Banta and Kamau 2007). While the findings of this body of research implies that the HIV/AIDS epidemic greatly affectschildren's well-being and survival, these studies can be criticized for their cross-sectional nature and the inability of the analyses to establish the HIV status of children and distinguish between direct and indirect effects of maternal HIV infection.

Prenatal care

Early and regular checkups by trained healthcare providers assess the physical status of women during pregnancy and insure appropriate interventions during delivery. Despite improvements in public health in recent decades, levels of infant and child (and maternal) mortality remain unacceptably high, particularly in low-income countries where primary healthcare services, including prenatal care, are not universally available (Hong and Ruiz-Beltran 2007). In Pakistan mothers who had one or no prenatal care visits during pregnancy were twice as likely to give birth to a low birth weight infant as mothers who had four or more visits (Janjua et al. 2009).

Hong (2006) observed in Bangladesh that prenatal care and access to safe drinking water were associated with lower risk of low birth weight and concluded, among other things, that screening for high-risk pregnancies and making referral services more accessible to rural women and children would improve child health and survival. Regrettably, in about one-third of births in Ghana the mothers have received no prenatal care (Hong, Banta and Kamau 2007). Children whose mothers received no prenatal care are more than twice as likely to die during the first year of life as as children whose mothers received prenatal care.

Birth in medical facility and presence of trained attendant at birth

More than half a million women, the majority of whom live in low-income countries, die from pregnancy-related complications each year (Mrisho et al. 2007; Otis and Brett 2008). Research has identified deficient resources, politics, and cultural differences as reasons. In Tanzania and Bolivia, Mrisho et al. (2007) and Otis and Brett (2008) found that women's place of delivery depended on their financial resources, access to transportation, labor conditions, staff attitudes at healthcare facilities, questions of privacy, decision- making power within the household, tradition and cultural patterns, including perceptions of birth. In particular, Mrisho et al. (2007) found that women in male-headed households were less likely to deliver in a healthcare facility than women in female-headed households. Younger mothers and mothers with primary and higher education were more likely to deliver at a healthcare facility than were older mother and those with less education.

In rural Tanzania, Mbaruku et al. (2009) report that two-thirds of women who gave birth in a health facility were very satisfied with the experience, compared with only 21.2% of those who delivered at home with traditional birth attendants (TBAs),. The skills of physicians and nurses were also rated higher than those of TBAs. Despite low ratings for TBAs in Zimbabwe, the absence of sufficient numbers of healthcare providers has made TBAs an indispensable portion of birth attendants. Women who deliver at home are, however, less likely to receive more than one recommended prenatal care service than women who deliver in a health care center (Perez et al. 2008). Trained birth attendants need not be physicians and nurses. Training of TBAs could improve prenatal care and delivery assistance in many African countries. Large scale demographic, socioeconomic, political and cultural contextual issues must be taken into account to effectively address the need for prenatal care and delivery assistance.

Vaccination status

Complete and timely immunization of young children is necessary to reduce morbidity and mortality due to numerous infectious diseases (Bloss, Wainaina and Bailey 2004). WHO recommends vaccination for six infectious diseases: diphtheria, pertussis, tetanus, measles, poliomyelitis, and tuberculosis. An additional benefit of increased vaccination coverage is its being the most cost-effective means of reducing strains on healthcare systems in many low-income countries (Bondy et al. 2009).

In Nepal, Bhandari, Shrestha and Ghimire (2007) found that the sociocultural background of children, their place of residence, parental education, household income, and access to health services were signiciantly associated with vaccination status. Bronte-Tinkew and Dejong (2005) observed in the Caribbean that household structure and economic resources predicted child vaccination status. Nuclear households had the highest proportion of fully immunized children compared with other household structures. Evidence indicates that no single factor explains children's vaccination status. In Trinidad and Tobago, household structure, single-parent status and variables that get at resource dilution—number of siblings and a child's age and birth order—combine to predict children's vaccination status. In Jamaica, the most significant predictor of immunization is the combined effect of household resources and child characteristics, although such other factors as caregiver's education, hours worked by the caregiver's partner and region of residence were also significant.

Research has linked vaccination status to children's nutritional status. For example, in Western Kenya, up-to-date vaccination status was significantly, negatively correlated with underweight and stunting. Children whose vaccinations were not up to date were more than twice as likely to be stunted as children with timely vaccinations (Bloss, Wainaina and Bailey 2004).

Oral Rehydration Therapy (ORT)

Diarrhea remains one of the leading causes of child mortality globally. Oral rehydration therapy (ORT) has been the cornerstone for treatment of dehydration for more than three decades. Munos, Walker and Black (2010) conclude from a systematic review of the effectiveness of Oral Rehydration Solution (ORS) and Recommended Home Fluids (RHF) on diarrhea mortality that while ORS is effective, evidence for the effectiveness of RHFs is insufficient. Migowa, Gatinu and Nduati (2010) found in Kenya that adherence to ORT was suboptimal and that among children with some dehydration, only 1 in 5 adhered to the correct ORT prescription. Li et al. (2009) reported that 14% of parents studied in Washington State in the U.S. used treatment methods for diarrhea in children not recommended by the Centers for Disease Control and Prevention (CDC) guidelines.

Improper treatment of diarrhea has serious consequences for children's health and nutritional outcomes. In three Central Asian Republics, Bomela (2009) found that the odds of being underweight were 2.1 times higher among children who had used oral rehydration therapy (ORT) compared to those whose mothers had only heard of ORT. The negative relationship was the result of a lack of understanding of infections as a cause of disease and improper use of ORT to treat diarrhea. Caregivers who believe that

ORT is intended to cure diarrhea (rather than to reverse dehydration) are likely to reject its use after observing that it does not.

Water supply and sanitation

At the household level, availability of safe drinking water and sanitary toilet facilities considerably reduces the levels of severe and moderate malnourishment (Bawdekar and Ladusingh 2008). Poor water and sanitation have been linked to increased risk of infections and malnutrition among children in many countries in Asia and Sub-Saharan Africa (Cuesta 2007; Merchant et al. 2003). Islam and Azad (2008) found that housing conditions and access to safe drinking water and hygienic toilet facilities are the most critical determinants of child survival in urban Bangladesh, even after controlling for migration status.

Cuesta (2007) found in the Philippines that while water and sanitation provision generally have a positive effect on nutritional status, household access to point source water and latrines are more likely than other public infrastructure to reduce the probability of malnutrition among poor households. Beyond the household, community-based piped water provision and flush toilets had the greatest potential to reduce malnutrition. In Libya, housing environment (type of dwelling, water supply, sanitation and garbage collection) was among the underlying determinants of stunting (El Taguri et al. 2009). Exposure to untreated water was associated with underweight but not with stunting in Kenya (Bloss, Wainaina and Bailey 2004).

In the Sudan, Merchant et al. (2003) examined the relation between household water and sanitation, on the one hand, and the risk of stunting and reversal of stunting, on the other. They found that among children of normal height-for-age at baseline, the risk of stunting was lowest in the group that came from homes with both potable water and sanitary waste disposal. Among children stunted at baseline, those whose homes had potable water and sanitary waste disposal had a 17% greater chance of reversing stunting than those coming from homes without either, after adjusting for age, sex, region, breastfeeding at baseline, vitamin A intake, socioeconomic status and mother's literacy. Water and sanitation independently were associated with child growth.

Food safety

Many urban residents in poor countries as well as prosperous ones rely on foods prepared “out of home” (Lachat et al. 2009). While these foods have increased dietary diversity for many, they have also raised concerns about food safety, particularly because contaminated water and food are major causes of morbidity and mortality associated with diarrhea among children in low-income countries. As mothers wean their infants from breastfeeding and introduce them to a mixed diet of fluids and foods, their immature immune systems are subjected a multitude of pathogens (Marino 2007).

Numerous studies have documented infectious disease related to diet, particularly in urban areas of low-income countries. In Brazil, Behrens et al. (2010) report a lack of awareness regarding potentially risky behaviors related to handling and storage of food. In India, Marthi (1999) observes that food safety enjoys a very low priority at all levels of preparation and consumption, and that awareness of the importance of hygiene and the seriousness of food-borne illnesses. However, a more recent study in the same setting by Rao et al. (2007) found that food safety awareness and practices were good among mothers. Home cooked foods were considered safer than purchased foods. Many mothers were also aware of the common food adulterants but did not complain or take action when they found them in purchased food.

Child care practices

Child care practices—along with diet, food security, environment, water and sanitation, and availability of health services—affect young children’s nutritional status. In many low-income countries, fathers tend to take a hands-off approach to child care, particularly while children are young. One study found that fathers of 13% of infants had no contact with their children, and among families with both parents present, 33% of the fathers reported not actively participating in their children's care (Falceto et al. 2008). A problematic relationship for the couple and mother’s status as a housewife were associated with lack of father involvement in infant care.

In Tanzania, Kulwa, Kinabo, and Modest (2006) found that most psychosocial practices (e.g., the caregiver's attention, affection, and involvement in child feeding, hygiene, health care, and training) were performed by mothers,Cooking, feeding and child training, were often done by alternative caregivers. They concluded that prevalence of chronic malnutrition and morbidity were high and that child-feeding practices were inadequate in the urban population. Maternal employment and educational characteristics constrained good childcare practices, resulting in alternative caregivers taking up more important roles in child care.

In Pakistan, Baig-Ansari et al. (2006) found that although poor urban residents had greater economic opportunities than their rural counterparts, they lacked the skills and knowledge to translate their resources into good care and feeding practices. In multivariate analysis they did not find a significant relationship between care and feeding practices, on the one hand, and child nutritional outcomes, on the other.

Education

Mother's education is widely acknowledged to be significantly associated with child nutritional outcomes. Numerous studies have found that parental education in general confers significant child nutritional advantages (Frost, Forste, and Haas 2005; Semba et al. 2008; Van de Poel et al. 2007; Van de Poel and Speybroeck 2009; Wachs 2008). However, a few studies bring into question the effect maternal education has on children's nutritional status (Hong and Mishra 2006). In Cambodia, maternal education had only a small effect on childhood stunting, and controlling for education did not much alter the effect of household wealth status on stunting (Hong and Mishra 2006). The majority (86%) of mothers in Cambodia have less than complete primary education or no education.

Nevertheless, it is widely believed that formal education increases mothers' knowledge and understanding of health and utilization of health care (Wachs 2008). Women with more education are more likely to be involved in household decision making concerning the allocation and use of family resources. Their involvement contributes to children's nutritional status and overall well-being. Many studies have found that mothers are more likely than fathers to allocate resources in ways beneficial to children.

Formal parental education was significantly associated with care-giving behaviors and stunting in children under age five in both Indonesia and Bangladesh (Semba et al. 2008). Greater formal maternal education resulted in 4.4%-5% and 4.6% decrease in child stunting, and greater formal paternal education decreased the odds of child stunting by 2.9-5.4% and 3%. Additionally, in Indonesia, high levels of maternal and paternal education were both associated with protective care-giving behaviors, including completing childhood immunizations, better sanitation, and use of iodized salt.

Assessing the relationship between parental and socioeconomic characteristics and nutritional status among children less than five years of age in Egypt, Rajaram, Zottarelli and Sunil (2007) observe that the odds of stunting decreased among children as parental educational level increased. For instance, the odds of stunting were lower among children whose fathers had at least secondary education than children of fathers with no education. Both maternal and paternal education is highly correlated with child stunting in many places. Encouraging both females and males to achieve more education could improve children's nutritional and health status.

Only a few studies have attempted to understand the mechanism by which parental education shapes children's nutritional outcomes. One of these points to socioeconomic status and utilization of modern health facilities as the most important pathways of influence between maternal education and child nutritional status (Frost, Forste, and Haas 2005). The context-specific nature of this study, however, implies that improved measures in different contexts are needed to further clarify the mechanisms through which maternal education influences child health outcomes. The mechanisms may differ for particular places and populations.

Employment

Healthy child development and improved economic opportunities for women are two general goals of development worldwide. Women's participation in the work force in developing countries has been steadily increasing over the last few decades. Many studies have linked the nutritional status of children to income-generating activities of mothers. Acharya (2003) observed in India that employment of mothers at home kept children in better nutritional health than unemployment or employment away from home and suggested that programs to improve the nutritional status of preschool children support mothers' employment at home. More recently, Chirwa and Ngalawa (2008) found that children in Malawi were better nourished if their households were headed by economically empowered females.

Not all types of maternal employment benefit children, however. In Mali, while maternal cash crop production was positively associated with children's weight-for-height, maternal staple food production was negatively associated with energy intake from foods other than breast milk (Pierre-Louis et al. 2007).

Basic Causes

National and sub-national distribution of resources

Improving nutrition in early childhood has been understood to be a long-term economic investment for developing countries. Provision of broad public goods and efforts to reduce poverty—like other factors in well-being—vary internationally and sub-nationally. In many low-income countries, resource distribution inequalities are best expressed in the wide gap between rural and urban areas. The rural-urban distinction in place of residence is one of the most studied correlates of child malnutrition (see Fotso 2007; Heaton and Forste 2003; Kennedy et al. 2006; Madhavan and Townsend 2007; Van de Poel et al. 2007).

In Bolivia, Heaton and Forste (2003) found that children in rural areas were twice as likely to die before the age of two as children in large cities and that approximately one-third of rural children were stunted. Only a third of the rural-urban difference was authors suggested that a substantial share of the rural-urban difference is attributable to the ecological and occupational dimensions of rurality, which may be hard to counter merely with infusion of resources.

While in general children's nutritional status is better in urban than in rural areas in low-income countries, some research hints at urban poverty's recently narrowing the rural-urban gap (Fotso 2007). In a survey of 15 Sub-Saharan countries that examined levels and trends in urban-rural differentials in children's nutritional status and whether child health was intrinsically better in urban areas given comparable socioeconomic status (SES) of households and communities, Fotso (2007) concludes that while urban-rural differentials are considerable in all countries, they have narrowed substantially in a number of countries (6 out of 13) primarily because of increases in urban malnutrition. In a few countries, however, differences have widened as a result of sharp declines in urban malnutrition. Urban-rural gaps disappeared in almost all countries when SES was controlled. The inclusion of father's education and mother's occupation did not significantly alter the results.

The contrast between Fotso's (2007) findings and others (Heaton and Forste 2003; Smith, Ruel and Ndiaye 2005) may be due in part to methodological differences. For instance, while Fotso (2007) defined stunting as a dichotomous variable and used logistic regression, other studies measured it as a continuous scale and used linear regression. Kennedy et al. (2006) demonstrate how slight methodological differences can lead to either widening or narrowing of rural-urban differences. In their examination of the relationship between childhood under-nutrition and poverty in urban-rural areas in the Central African Republic and Senegal, they showed that in all cases, using a simple urban/rural dichotomy instead of stratification by wealth resulted in significantly higher stunting prevalence in rural areas. When urban and rural populations were stratified by a wealth measure, the differences in prevalence of stunting and underweight between urban and rural residents disappeared. This implies that simple urban/rural comparisons mask wide disparities in subgroups that are revealed only by using wealth measures, and that there is a strong relationship between poverty and chronic undernourishment in both urban and rural areas.

International distribution of resources and political economy

The factors affecting child well-being at the local scale do not operate in a vacuum but rather reflect processes that originate at the global scale and permeate what occurs at national and local scales. The concept of globalization, popularized in the 1990s, lacks both a single definition and agreement about its precise nature and impact (see Held and McGrew 2007; Hirst and Thompson 1997; Moghadam 1999; Streeten

2001). While some see it as referring to both liberalization and increase in trade of goods and services and international movements of capital, technology, marketing and management, others have characterized it as a spatio-temporal process of change which underpins a transformation in the organization of human affairs by linking together and expanding human activity across regions and continents.

However globalization is conceptualized, its diverse impact on populations across the globe is indisputable (Moghadam 1999; Muchie and Xing 2006; Streeten 2001). While globalization has helped to create undreamed of opportunities for some people — particularly in North America, Western Europe and East and Southeast Asia —at the same time the accompanying economic restructuring, liberalization, technological change and fierce competition have contributed to increased impoverishment, inequality, work insecurity, weakening of institutions and social support systems, and erosion of established identities and values. For instance, social expenditure as a percentage of total government expenditure for all developing countries declined from 35% to 27% between 1972 and 1986 (Streeten 2001, 22).

These observations were confirmed by the United Nations Development Program (UNDP) in its 2003 report. Globalization was initially seen as the great new motor of worldwide economic progress and assumed to be the means by which poor countries could achieve economic growth as long as they pursued sound economic governance, based on the precepts of macroeconomic stability, liberalization of markets and privatization of economic activity. Economic growth, in turn, was expected to bring widespread improvements in nutrition, health, education, housing and access to basic infrastructure —enabling countries to break free from poverty. But as globalization systematically benefited some regions of the world, it bypassed others. In the 1990s most of Southeast Asia saw living standards improve dramatically. However, large parts of Sub-Saharan Africa, parts of Eastern Europe and the Commonwealth of Independent States (CIS) and many countries in Latin America and the Middle East did not (UNDP 2003).

In view of this, Streeten indicates in his "balance sheet of globalization that those who have benefited most from globalization are those with assets and high skills: the educated, flexible adjusters, multinational corporations, creditors, and sellers of technologically sophisticated products. The most negatively affected by globalization include those without assets, rigid adjusters, people with few skills, those dependent on public services, the uneducated, workers, women and children, local communities and sellers of primary and standard manufactured products. For these and many other reasons, Streeten (2001, 27-28) notes, "Globalization has been bad for Africa .… International competition for markets and jobs has forced governments to reduce taxation and with it the social services that had protected the poor, and cut those public services and regulations that had protected the environment."

Moghadam (1999, 377) observes that although globalization has opened avenues for women to participate in paid jobs, the austerities of structural adjustment and other stabilization policies in much of Africa and Latin America has meant that women and children have to bear the greater burden of "price increases, elimination of subsidies, social-service decreases, and introduction or increase of 'user fees' for 'cost recovery' in the provision of schooling and health care." At the same time, women suffer income inequality in most jobs. Caution should however be exercised about the impact of globalization, which cannot rightly be blamed for all woes. What is unmistakable though is evidence that globalization has exacerbated problems that existed before its onset.

Chapter 3

DATA AND METHODS

Data Sources

This study employs data from the 2008 Ghana Demographic and Health Surveys (GDHS) as outcome (dependent) variables documenting the differential nutritional status of Ghanaian children. It uses information from this same survey, environmental maps, and the 2000 Ghana Population and Housing Census as explanatory (independent) variables hypothesized to be significantly associated with indicators of nutritional status.

Demographic and Health Surveys (DHS)

The MEASURE Demographic and Health Surveys (DHS) are generally recognized as the most accurate source of nationally representative information about demographic and health characteristics of low-income countries, with an emphasis on young children and their mothers. Selection of the DHS stratified sample for every survey entails two stages. 1) Enumeration areas (Prost et al. 2008) or population clusters, based on the national census, are randomly selected with probability proportional to the number of households there. 2) Then, after the list of households in each of the selected EAs has been updated, those where interviews will be conducted are randomly selected with equal probability (MEASURE DHS 2010c). Standardized modules are used to construct questionnaires for each national survey. The questionnaires and instruction manuals for interviewers for a particular survey are revised after pre-testing. Staff members of ICF Macro (formerly called ORC Macro and then Macro International—see below) provide technical support in the training of interviewers and subsequent fieldwork (MEASURE DHS 2010c). The standardization to which DHS adheres allows systematic comparisons of results among countries and for a single country chronologically over several surveys.

What is remarkable about DHS data—in contrast to national census data, for example—is that variables are reported for individuals and their households. This enables multivariate analysis at the level of individual, thus avoiding the ecological fallacy. The individual child is the most logical unit of analysis for research on childhood malnutrition, since it is he or she who consumes food, experiences infectious diseases, and exhibits a particular nutritional status.

Since 1984, more than 240 surveys have been conducted in eighty-four countries (MEASURE DHS 2010a). They provide information about, for example, contraception and fertility, prenatal care, breastfeeding, nutritional status of mothers and children, children's immunization status, use of maternal and child health services, infant and child mortality, and awareness and behavior regarding AIDS. Most recent surveys include testing for anemia, diabetes, and HIV infection. Recent surveys in Ghana and some other countries have included information about malaria and malaria prevention.

The U.S. Agency for International Development (USAID) funds DHS, with contributions from the national governments of some of the countries where surveys are conducted and from numerous international organizations, including the World Health Organization (WHO), the United Nations Children's Fund (known as UNICEF, based on its original name, the United Nations International Children's Emergency Fund), the Joint United Nations Program on HIV/AIDS (UNAIDS), and the United Nations Population Fund (UNFPA, based on its former name, the United Nations Fund for Population Activities). In 2003, Macro International, a private research firm, assumed responsibility for overseeing the MEASURE DHS project. In 2009, ICF International acquired Macro International, which was renamed ICF Macro (ICF 2009).

The stated mission of MEASURE DHS comprises the following:

- collecting data . . . useful in policy formation, program planning, and monitoring and evaluation
- host country ownership of data collection, analysis, presentation, and use
- coordinat[ion] with key stakeholders on data collection and dissemination
- select[ion of] the most appropriate data collection methods to ensure the provision of high-quality data at a reasonable cost
- increas[ing] the capacity of host-country partners to collect and use data for program and policy purposes (MEASURE DHS 2010a).

Since 2008, the Bloomberg School of Public Health at Johns Hopkins University, the Program for Appropriate Technology in Health (Allotey and Reidpath 2001), and other institutions have collaborated in expanding the accessibility and utilization of DHS data.

DHS in Ghana

Ghana's first DHS was carried out in 1988. Four additional surveys were conducted in 1993, 1998, 2003 and 2008. The Ghana DHS (GDHS) has strengthened the technical capacity of major government institutions, including the Ghana Statistical Service (GSS) and the Ghana Health Service (GHS), and enabled monitoring of the country's demographic and health status over a span of two decades.

In 2008, 412 enumeration areas (Prost et al. 2008) were randomly selected from a list based on the 2000 Ghana Population and Housing Census.[2] Interviews were conducted in 11,778 households for the 2008 GDHS, with response rates of 97% for women and 96% for men (GSS, GHS and ICF Macro 2009, 1). These samples are considered representative for Ghana as a whole, for urban and rural areas, and for the country's ten official regions.

The final report for the 2008 GDHS (GSS, GHS and ICF Macro 2009) has been published. Table 1 compares selected indicators from the 2003 and 2008 Ghana Demographic and Health Surveys

[2] In the 2008 Ghana Demographic and Health Surveys, EAs from the 2000 Population and Housing Census for Ghana were first stratified into the country's ten administrative regions, then into rural and urban EAs, before selection of households for interviewing. For details, see GSS, GHS and ICF Macro 2009, Appendix A.

Table 1: Comparison of selected indicators from the 2003 and 2008 Ghana Demographic and Health Surveys

Indicator	2003	2008
SURVEY SAMPLE		
▪ Number of households where interviews were conducted	6,251	11,778
▪ Number of women interviewed	5,691	4,916
▪ Number of men interviewed	5,015	4,568
HOUSEHOLD CHARACTERISTICS		
▪ Mean number of individuals	4.0	3.7
▪ Percentage of households headed by female	33.8	33.7
▪ Percentage of households with electricity	48.3	60.5
▪ Potable water/water source]	16.4	14.2
▪ [sanitary waste disposal]	10.7	7.2
MEN'S CHARACTERISTICS		
▪ No formal education (percentage)	17.6	13.3
▪ At least some primary education (percentage)	16.0	15.3
▪ At least some middle school/junior secondary education (percentage)	43.2	42.4
▪ At least some secondary education (percentage)	23.2	28.8
▪ Median years of formal education	8.3	8.5
▪ HIV prevalence (percentage)	2	-
WOMEN'S CHARACTERISTICS		
▪ No formal education (percentage)	28.2	21.2
▪ At least some primary education (percentage)	20.0	20.1
▪ At least some middle school/junior secondary education (percentage)	40.0	41.5
▪ At least some secondary education (percentage)	11.8	17.2
▪ Median years of formal education	6.2	7.2
▪ HIV prevalence (percentage)	3	-
▪ TFR (total fertility rate)	4.4	4.0
▪ Currently married women's ideal family size	4.8	4.6
▪ Contraceptive rate for currently married women (percentage)	25	24
PRENATAL CARE AND DELIVERY		
▪ Percentage of women receiving prenatal care for most recent birth within previous five years	92	95
▪ Percentage of births in health care facilities	46	57
▪ Percentage of births attended by trained health care providers	47	59
INFANT MORTALITY		
▪ Infant mortality (mortality before age one per 1,000 live births)	64	50
CHILDREN'S CHARACTERISTICS		
▪ Percentage of children age 12-23 months who were fully immunized	69	79
▪ Percentage of children age 12-23 months who had received no vaccination	5	1
▪ Acute respiratory infection during previous two weeks (percentage)	10	6
▪ Diarrhea during previous two weeks (percentage)	15	20
▪ Fever during previous two weeks (percentage)	21	20

▪ Ever breastfed (percentage)	97	98
▪ Median duration of breastfeeding (months)	23	20
▪ Percentage of children age 6-59 months who received vitamin A supplement in previous six months	78	56
▪ Percentage of children age 6-59 months with mild anemia	23	23
▪ Percentage of children age 6-59 months with moderate anemia	47	48
▪ Percentage of children age 6-59 months with severe anemia	6	7
▪ Percentage of children under age five who were stunted (low height for age)	30	28
▪ Percentage of children under age five who were severely stunted (low height for age)	11	10
▪ Percentage of children under age five who were underweight (low weight for age)	22	14
▪ Percentage of children under age five who were severely underweight (low weight for age)	5	3
▪ Percentage of children under age five who were wasted (low weight for height)	7	9
▪ Percentage of children under age five who were severely wasted (low weight for height)	1	2

Source: GSS, NMIMR and ORC Macro 2004, GSS, GHS and ICF Macro 2009

Consistent with the goal of DHS to make survey data systematically comparable between countries and within the same country between surveys, the table above shows that although GDHS 2003 and 2008 were conducted 5 years apart, the survey outcomes are not markedly different. For instance while nearly twice as many households completed interviews in the GDHS 2008 compared to GDHS 2003, the difference between the number of women and men interviewed in the two survey periods were off by only 775 and 447 respectively. Also, the change for a number of respondent characteristics was no more than one percent between the survey periods. Those that changed by more than five percentage points between surveys include women with no formal education (declined by 7%); percentage of births in health care facilities (increased from 11%); percentage of births attended by trained health care providers (increased by 12%); diarrhea during previous two weeks (increased by 5%); Percentage of children age 6-59 months who received vitamin A supplement in previous six months (declined by 22%); and infant mortality (declined from 64 to 50 per 1,000 live births).

Ghana Population and Housing Census

Another source of data for this study is the 2000 Ghana Population and Housing Census (PHC). This census is the fourth post-independence Population Census in Ghana, the other three being 1960, 1970 and 1984 population censuses. The three earlier post-independence censuses however did not collect detailed information on housing. The 2000 PHC is the first time Ghana collected census information on both population and housing. The census was carried out by the Ghana Statistical Service and covered all persons in households and all living quarters in Ghana at midnight of Census Night (March 26th, 2000).

The census collected information on topics as household relationships, sex, age, birthplace, nationality, and school attendance, type of economic activity, occupation, industry, and employment status. In addition, information on ethnicity, usual place of residence and place of residence in the previous five years, religion, marital status, literacy, institutions, fertility and mortality and housing conditions was collected. Questions on housing conditions collected information on type of dwelling, main construction materials, holding/tenure arrangement, ownership type, number of rooms, type of lighting, water supply and toilet facilities, cooking fuel, cooking space, bathing facilities, solid waste disposal and liquid waste disposal.

Nutritional Outcome (Dependent) Variables

The purpose of this study is to examine child well-being in Ghana. This is achieved by assessing child nutritional outcomes because it secures all other components of child well-being. Among various growth-monitoring indices, there are three commonly used anthropometric measures that offer a comprehensive profile of a child's nutritional status: stunting, underweight and wasting, measured by the indices height-for-age, weight-for-age and weight-for-height, respectively. Other measures of nutritional profile identified in the literature are hemoglobin, body mass index (BMI), mid-upper arm circumference (MUAC) and measurements of vitamin A and zinc.

In this study, height-for-age, weight-for-age and hemoglobin are used as outcome variables. Height-for-age is included because it is the most widely used of all the indices of child nutrition in almost all the studies consulted (see Fotso 2007; Fotso and Kuate-Defo 2006; Frost, Forste and Hass 2005; Rajaram, Zottarelli and Sunil 2007). Although weight-for-age is a composite variable and therefore relatively challenging to interpret, it is included in this study because it is the second most prevalent cause of malnutrition in Ghana, impacting 14% of all children under age five in the country. Hemoglobin is also included as an outcome variable in this study because the level of anemia among young children in Ghana exceeds the 40% cutoff considered a major public health concern by the World Health Organization.

Information for assessing the physical growth and nutritional status of children aged 0-59 months was obtained by measuring their height/length and weight during the GDHS survey. Weights were measured using a lightweight scale with a digital screen display and heights were measured using a measuring board. Children younger than 24 months were measured lying down on the board, and standing height was measured for older children. Valid height and weight measurements were obtained for 2,592 children in the 2008 GDHS (GSS, GHS, and ICF Macro 2009).

The GDHS also tested children aged 6-59 months for anemia in every second household selected for the sample. Anemia levels were determined by measuring the level of hemoglobin in the blood, with a decreased concentration characterizing anemia. For hemoglobin measurements, a drop of capillary blood was taken with a finger prick (using sterile, disposable instruments). Hemoglobin concentration was measured using the HemoCue photometer system. Generally, hemoglobin concentration of 100 —109 g/L is considered mild anemia, with concentrations of 70 —99 g/L and less than 70 g/L respectively considered moderate and severe anemia (GSS, GHS, and ICF Macro 2009).

The height-for-age and weight-for-age analyses in this study are based on 2,380 children aged 0–59 months included in the 2008 GDHS and the hemoglobin analysis is based on 2040 children. Height-for-age and weight-for-age data were missing or flagged for 20.3% of children and hemoglobin data was missing or flagged for 27.5% of children. The analysis excluded all children with missing or flagged data.

Height-for-age

Apart from the high prevalence of stunting in Ghana, height-for-age was included as an outcome variable in this study because it is less sensitive to temporary food shortages and considered the most reliable indicator of children's nutritional status, especially for the purpose of differentiating socioeconomic conditions (Fotso 2007).

Although DHS captures height-for-age as a continuous variable, most recent nutritional studies have treated it as a categorical response variable (see Balk et al. 2005; Frost, Forste and Hass 2005; Hong 2007). In these studies, children with height-for-age z-score below minus two standard deviations (-2 SD) from the median of an internationally referenced population are considered short for their age (stunted) and therefore chronically malnourished (Rahman and Chowdhury 2007). Children who are below minus three standard deviations (-3 SD) from the median of the reference population are considered severely stunted (de Onis, Frongillo and Bossner 2000; Ergo, Gwatkin and Shekar 2009).

Height-for-age data for Ghana was captured by the GDHS as a continuous variable ranging from -5.68 to 5.96 (z-score). For the purposes of this study, height-for-age data was categorized into stunted and not stunted. Stunted children were defined as those with height-for-age Z-score measures below -2 standard deviations from the National Centre for Health Statistics/World Health Organization (NCHS/WHO) recommended median reference population. The stunted category in this study therefore includes both moderately and severely stunted children and is similar to how Hong and Mishra (2006) defined it in an earlier study in Cambodia. The 'not stunted' children were defined as those with height-for-age Z-score greater than or equal to -2 standard deviation from the median population reference. In order to make the findings from this study easily comparable to other previous studies in Ghana (which were based on the old NCHS/WHO reference standard), the new WHO recommended reference standard was not used in this study.

Weight-for-age

As indicated earlier, weight for age was included in this study because although its prevalence has declined from 2003 levels, it is still the second most important form of malnutrition in Ghana, afflicting some 14% of children under age five. Like stunting, underweight data was captured by the GDHS as a continuous variable ranging in value from 4.61 to 5.62 (z-score), but like most studies it is analyzed as a categorical variable. Children with weight for age z-score below -2 SD of the NCHS/WHO reference median value are considered underweight. Children with weight for age z-score below -3 SD of the reference median population are considered severely underweight. In this study, children were classified as either underweight or not underweight based on the cutoff value of -2 SD below the NCHS/WHO median reference population. Underweight children were those whose weight for age z-score fell below the NCHS/WHO cutoff value of -2 SD and those whose weight for age z-score fell above this cutoff value were designated as not underweight.

Hemoglobin

This study included hemoglobin as an outcome variable because of the high prevalence of anemia in Ghana. The most recent demographic and health survey report for Ghana indicates that 78% of children have some level of anemia, with 48% being moderately anemic and 7% severely anemic. Anemia prevalence in Ghana also varies by age, and sex and place of residence with boys being slightly more anemic (79%) than girls (77%) and anemia being higher in rural areas (84%) than urban areas (68 %) (GSS, GHS, and ICF Macro 2009).

Like the two outcome variables above, the GDHS captured hemoglobin as a continuous variable ranging between 0g/L and 1,590g/L, but for the purposes of this study, two categories of hemoglobin were created. Children whose blood hemoglobin levels were below 1100 g/L were classified as anemic and those with blood hemoglobin levels above 1100 g/L were classified as not anemic. A similar classification was used by Tengco et al. (2008) to examine anemia among preschool children in the Philippines and

Ohlund et al. (2008) to study predictors of iron status in well-nourished 4 year olds in Sweden.

The children included in this analysis were those present at the time of testing, had parental consent to be tested and had plausible hemoglobin results. Although hemoglobin levels vary by altitude and should be adjusted accordingly, adjustments for altitude were not made in the GDHS because none of the children surveyed in Ghana lived above 1,000 meters.

Weight-for-height

This represents the failure to receive adequate nutrition in the period immediately preceding the survey and is usually the result of short-term inadequate food intake or a recent episode of illness causing loss of weight and the onset of malnutrition (Heltberg 2009). Like height-for-age, children with z-scores below -2 SD are considered thin (wasted) and acutely malnourished. Children whose weight-for-height is below -3 SD are considered severely wasted (GSS, GHS, and ICF Macro 2009). Weight-for-height was excluded from this analysis because of its low prevalence in Ghana. The final report of GDHS 2008 shows that although there was a slight uptick in the percentage of children under age five who were wasted and severely wasted (low weight for height) from 7% and 1% in 2003 to 9% and 2% in 2008 respectively, wasting is not as prevalent as the other nutritional outcome variables discussed above. Other studies that excluded wasting from child nutrition analysis because of its low prevalence include Bomela (2009) and Anthamatten (2007). Ergo, Gwatkin and Shekar (2009, 4) also argued that "Although wasting may be a good indicator to use in emergency situations, it is less pertinent in normal situations." They therefore excluded it from their analysis.

Exposure Variables

The research scholarship reviewed above showed that a large number of variables are associated with child nutritional outcome. These include such child characteristics as age of child, sex, birth weight and birth order, breastfeeding status; mother characteristics such as education, age at first childbirth, body mass index (BMI), birth interval, poverty, number of prenatal visits; and household characteristics such as father's education, parental consanguinity, Household economic status (wealth index); household composition and size, household assets; and district characteristics as rural-urban place of residence, region of residence, altitude, access to public services, immigration, community SES, low soil fertility (as measured by sandy soil constraint) (see Balk et al. 2005; Fotso 2007; Fotso and Kuate-Defo 2006; Frost, Forste and Hass 2005; Hong 2007; Hong and Mishra 2006; Hong and Ruiz-Beltran 2007; Morales, Aguilar and Calzadilla 2004; Shin 2007; Van de Poel et al. 2007).

The GDHS 2008 surveyed a large number of variables that include child's age, mother's age at first birth, education, residential history, media exposure, knowledge and use of family planning methods, fertility preferences, antenatal and delivery care, breastfeeding and infant and child feeding practices, vaccinations and childhood illnesses, childhood mortality, marriage and sexual activity, woman's work and husband's background characteristics, and awareness and behavior regarding AIDS and other STIs, source of drinking water, electricity supply, type of toilet facilities, flooring materials, ownership of various consumer goods and wealth indicators, ownership and use of mosquito nets, and number of children under age five (GSS, GHS, and ICF Macro 2009).

Since the GDHS 2008 did not collect data on all the variables identified in the literature to be relevant to child health and nutrition and not all the data collected in the GDHS 2008 are relevant to the subject matter of this study, the variables included in this study and how they were defined are discussed below.

Child Characteristics

Sex

There is a disconnect between the strong preference for boys in many developing countries and recent research findings that show that boys are more likely than girls to suffer nutritional deficiency. Since two previous studies in Ghana (Hong 2007; Van de Poel et al. 2007) have already shown that boys are more prone to malnutrition than girls, the inclusion of sex in this analysis is intended to both confirm these earlier findings and sharpen the analysis of the factors that explain child nutritional outcomes in Ghana. The 2008 GDHS asked every woman interviewed to provide a detailed history of all her live births in chronological order, including sex of the child. In this study, the sex of a child is defined as a binary variable that equals 0 if the child is male and 1 if the child is female. If there is a sex bias in the care of children, this study expects to find male children better nourished than female children or vice versa.

Age

The age of a child affects not only what they eat but how much of it they eat. Most studies have shown that while child nutritional status is unremarkable before age 12 months, growth deficit accelerates rapidly afterwards as children are weaned from breast milk and introduced to other food sources. The age ranges of critical importance to child malnutrition have been identified in many studies to be 13-24 months and 25-36 months (Bloss, Wainaina and Bailey 2004; Marins and Almeida 2002). Hong and Mishra 2006 observed that prevalence of stunting was considerably less common in the first six months of life but increased rapidly up to 12-23 months of age after which it increased more slowly. Although the GDHS 2008 captured child age as a continuous variable in months, the practice in many recent nutritional studies have been to categorize age. Rajaram, Zottarelli and Sunil (2007) for instance had five child age categories (0–11 months, 12–23 months, 24–35 months, 36–47 months or 48–59 months) with age < 12 months as the reference but Van de Poel et al. (2007) had three categories (≤ 6 months--reference; 6–12 months, >12 months) with age ≤ 6 months as the reference.

Based on these categories, this study created four child age categories from the original continuous age variable as follows: 0-12 months (0), 13-24 months (1), 25-36moths (2) and >36 months (3); with age 0-12 months as the reference. A similar classification was used by (Singh et al. 2009) in their study of underweight and stunting among children in Nepal.

Birth weight

A child's vulnerability to illnesses and whether they survive depends a lot on their weight at birth. Like many developing countries, some babies in Ghana are not weighed at birth because they are born outside of health facilities where they have the highest chance of being weighed (GSS, GHS, ICF Macro 2009). For all births in the five years preceding the survey, the 2008 GDHS recorded birth weights from available written records or mother's recall. Respondents who could not recall the birth weight of their children were asked to estimate the size of the baby at birth in terms of whether they were 'average', 'smaller than average', or 'very small'. Given the high likelihood that children born at home would not be weighed at birth and the possibility of bias in mother's recall of child weight at birth, the precision of birth weight values are very questionable. This study therefore used the qualitative descriptions of child weight at birth as indicated by the "size of child at birth" variable. The assumption is that mothers would be more likely to correctly estimate this kind of birth weight than an actual weight value. The 2008 GDHS originally captured six categories of child size at birth but for the purposes of this study three categories were created: large (combined larger than average and very large categories) = 0, small (combined smaller than average and very small categories) = 1 and average = 2. The average child size at birth was used as the reference.

Vaccination status

Children in Ghana are vaccinated according to the World Health Organization (WHO) and UNICEF guidelines for vaccinating children. Thus children who receive one dose of each of BCG and measles, three doses of polio vaccine, and three doses of DPT are considered fully vaccinated. The DPT vaccine has since 2002 been replaced by DPT/HepB/HiB vaccine. A complete vaccination schedule is recommended for all children before 12 months of age (GSS, GHS, ICF Macro 2009).

In the 2008 GDHS, vaccination coverage information was obtained either from health cards (where available) or the verbal reports of mothers (if they could not produce a health card). The survey produced eight separate results for the recommended vaccinations, each with four categories. For the purposes of this study, age appropriate vaccinations were combined for each child and recategorized as follows: 0 = fully immunized (if the child received all age appropriate vaccinations), 1 = not immunized (if the index child received no vaccinations at all or was marked as 'DK' - don't know), 2 = partially immunized (if the child received some age specific vaccinations).

This way of categorizing the vaccinations means that infants who received the recommended BCG/OPV 0 dose at birth but were less than one month old at the time of the survey were considered fully immunized for their age while 23 months old children with seven out of eight vaccinations were considered partially immunized for their age. The percentage of children that fell in each category was compared with the 2008 GDHS final report and found to be similar. The vaccination categories used in this study improves on Hong (2007) dichotomous treatment of this variable in a similar study in Ghana.

Oral Rehydration Therapy (ORT)

In Ghana more than half of all children with diarrhea were treated with ORS in 2008 (GSS, GHS, ICF Macro 2009). In rural areas, children were less likely to receive ORS if their mother's had no education or fell in the lowest wealth quintile. The 2008 GDHS elicited information from mothers about whether any of their children under age five years had diarrhea during the two weeks preceding the survey. For children who had experienced diarrhea, mothers were further asked about their feeding practices during the diarrhea episode and what treatment actions they pursued. As important as this variable is to children's health and nutritional status, this study did not include it in the analysis because it had more missing responses (85%) than valid (15%).

Mother Characteristics

Sociocultural at the household and individual level

Variables used in this study to represent sociocultural characteristics at the household and individual level include sex of household head, marriage type, ethnicity and household size. These variables have been shown in many previous studies to impact child health and nutritional outcomes particularly in the African setting (see Andoh et al. 2007; Bronte-Tinkew and Dejong 2005; Gage 1997; Gymah 2009; Leroy, Razak and Habicht 2008).

Previous studies show that men and women differ in the way they appropriate resources for child care resulting in significantly different child well-being outcomes. The 2008 GDHS report indicates that while the majority of households (66%) are male headed, 34% of households are headed by women (GSS, GHS, ICF Macro 2009). In this study, the sex of household head was defined as male (0) and female (1), with male as the sex of reference. Marriage type, defined as either monogamous (0) or polygamous (1) was also analyzed in this study for its specific impact on children in Ghana. Many studies have documented how polygamy impacts child nutritional outcome and survival in a number of African countries (see (Leroy, Razak and Habicht 2008).

Ethnicity was also included in this study because it is the most basic form of social organization in Ghana. The mother's ethnicity was used as the basis for comparison because the 2008 GDHS captured only mothers and not father's ethnicity. The survey data captured nine ethnic groups and Gyimah (2009) argues for using all the groups as captured, but this study collapsed a number of them because of their cultural similarities to create five groups: (0) Akan, (1) Ga/Dangme, (2) Ewe, (3) Mole-Dagbani and (4) Guan/Other. The Akan ethnic group was used as the reference against which the other ethnic groups were assessed.

Finally, the "number of household members" variable was used to evaluate household size in this study. Studies in the Caribbean and Africa show that in large families, resource dilution is a real problem leading to intra-household competition for food and attention among children (Andoh et al. 2007; Bronte-Tinkew and Dejong 2005). Although the average size of households in Ghana is about 4 persons, the 2008 GDHS data shows that households can be as large as 22 persons because of the extended family phenomenon. While Bondy et al. (2009) created a binary variable for number of household members (2-5 and 6-22) in a study in the Philippines, the present study created three categories (1-6, 7-10, and >10 members) for number of household members variable. The appropriateness of this categorization is confirmed by (Hammer et al. 2006) who used similar categories in a Sub-Saharan African study. In addition to the number of household members, specific attention is also given to the number of children under five years in the household because of the implications this has for resource allocation among children.

Mother's age at child's birth

Mother's age at first birth has serious demographic implications for the health and welfare of the mother, child and the society in general. Women who marry early are more likely to be exposed to pregnancy and child bearing early and therefore raise a larger family, particularly in societies with low contraceptive usage. Younger mothers have also been shown in the literature to have lower capacity to handle all the challenges of child bearing and care, exposing their children to poorer health and a lower chance for survival.

Most studies that included mother's age at first birth in child health and nutrition analysis classified the variable differently. Although Hong and Mishra (2006), Janjua et al. (2009) and Van de Poel and Speybroeck (2009) split maternal age at birth into three categories they defined the categories differently as <20 years, 20-40 years, >40 years; <20, 20–30 and ≥30 years and 15-24, 25-34, 35-49 years respectively. Bondy et al. (2009) on the other hand measured mother's age at first birth continuously. These differences could be attributed to context and the subject matter under study.

While mother's age at first birth was captured in the 2008 GDHS data as a continuous variable ranging from 12-38 years, the present study created three 'mother's age at first birth' categories as follows: <20 years, 20-30 years and >30 years. The age group of reference is 20-30 years. Given the range of the data this classification is reasonable because it captures the important groups in the data.

Mother's nutritional status

Poor maternal nourishment as measured by low body mass index (BMI), short stature, or other micronutrient deficiencies has been shown in many studies to complicate child birth and lead to low birth weight babies, poor quality breast milk, greater risk of ill-health for mother and baby and even death from post-partum hemorrhage. BMI measures thinness or obesity and is the most often used measure of mother's nutritional status in many studies. It is a ratio that compares weight in kilograms to the square of the height in meters (kg/m^2) (Dharmalingam, Navaneetham and Krishnakumar 2010).

According to international standards set by the WHO, an adult is considered underweight if BMI is <18.50kg/m^2, normal if BMI is 18.5-24.9kg/m^2, overweight if

BMI is ≥25 kg/m^2 and obese if BMI is ≥30 kg/m^2. Studies by Rahman and Chowdhury (2007) and Dharmalingam, Navaneetham and Krishnakumar (2010) in Bangladesh and India respectively used slightly different classifications of BMI to study chronic malnutrition and low birth weight. Given the BMI range of 13.91kg/m^2 to 59.43kg/m^2 in the 2008 GDHS data, the present study adapted the international BMI cutoff values described above to study the effect of mother's nutritional status on child nutritional outcome. A similar classification was used by Hong, Banta and Kamau (2007) in their study of maternal HIV and child survival in Ghana. All missing or flagged data were excluded from the analysis.

Mother's health status

The HIV/AIDS epidemic in Sub-Saharan Africa has rolled back a lot of progress in child survival in the past two decades (Hong, Banta and Kamau 2007). Masanja et al. (2008) documents some progress in the reduction of HIV/AIDS in Tanzania but for the vast number of countries on the continent and in many developing countries, the epidemic continues to wreak havoc on child survival.

Due to the sensitivity of HIV/AIDS data, DHS makes it available in a separate data file in which HIV status is linked to very limited set of demographic variables, making it nearly impossible to locate individual respondents. Mother's HIV/AIDS status is therefore not analyzed in this study. Instead, the impact of mother's health status on child nutritional outcome is assessed using mother's hemoglobin status. Although knowledge about the impact of maternal hemoglobin status on child health and nutritional outcome is limited, one study by Ohlund et al. (2008) has linked them. In the 2008 GDHS data, mother's hemoglobin was captured as a continuous variable ranging between 350 g/L and 1,670 g/L, but in this study a binary category was created for mother's hemoglobin. Mothers with blood hemoglobin levels below 1100 g/L were classified as anemic and those with blood hemoglobin levels above 1100 g/L were classified as not anemic.

Prenatal care

Prenatal care helps to identify and treat pregnancy related problems before they become life threatening to the mother and child. Typical services provided include screening for complications, birth preparedness and referral of mothers with complication. Although prenatal care is high in Ghana, most mothers are more likely to seek prenatal care for their first birth than for higher birth orders. Rural-urban place of residence and women's educational level are also important for determining prenatal care. Studies that analyzed maternal prenatal visits differ in how they categorized this variable, with context and subject matter being key considerations. In Nigeria and Ghana, Kandala et al. (2007) and Hong, Banta and Kamau (2007) used a binary category to indicate whether mothers had prenatal visit or not, but (Janjua et al. 2009) focused on the number of visits during pregnancy and used three categories (≤1, 2-3, ≥4) in a study in Pakistan. Others categorized prenatal care based on whether it was by a health professional or not (Hong and Ruiz-Beltran 2007). Given the range of responses to this question in the 2008 GDHS data, this study categorized the number of maternal prenatal visits into <3, 3-9, >10, with <3 visits as the reference category.

Birth in medical facility

Skilled assistance at birth is essential for safe delivery care but factors such as cost of service, distance to health facilities, particularly in rural areas, and the quality of care prevent many women from seeking help from medical facilities, even when they are aware of possible complications at delivery and the implications of not utilizing professional help.

In the 2008 GDHS, respondents were asked to report the place of birth for all their children born within five year of the survey. Because mothers were unlikely to misreport the place where they had a birth, data on place of childbirth tend to be fairly accurate. In this study, the place of delivery variable was used to examine how birth in a medical facility impacts children's nutritional outcome. This variable originally had 11 categories but, for the purposes of this study, was recategorized into four by combining similar categories as follows: 0 = public health facility (reference), 1 = private health facility, 2 =

home/other. Similar categories were used by Johnson, Padmadas and Brown (2009) who coded the place of delivery into three categories: births at home (reference) and those in institutions, with institutions further categorized into private and public institutions.

Trained attendant present at birth

The 2008 GDHS reports in 2008 health professionals (doctors, nurses, midwives, auxiliary midwives and community health officers) assisted the delivery of 59% of births in Ghana while traditional birth attendants assisted the delivery of 30% of births. Since the literature indicates that health professional assisted deliveries are safer, this study focused on how traditional birth attendants impact child survival in Ghana. The two categories used in the analysis are (0) not assisted at birth by traditional birth attendant (trained) and (1), and assisted at birth by a traditional birth attendant (trained). These categories are similar to those used by Hong and Ruiz-Beltran (2007) in Bangladesh even though they focused on professional assistance at delivery.

Household Characteristics

Wealth

Levels of parental education and family income have traditionally been used to quantify socioeconomic status (SES), but recently many researchers and institutions, including the World Bank, have supported the use of household asset indices for this purpose because of the unreliability of income measures in resource-poor contexts. Assets (e.g. radio, television, refrigerator, and others) and building characteristics (e.g. type of floor, walls, number of rooms) now form the basis for constructing a single, consolidated index of living standards, using principal components analysis to generate a weight for each item. All mothers and children living in a household are assigned a standardized wealth index score, which is then divided into quintiles—poorest, poor, middle, rich, and richest (Barros et al. 2010).

In Cambodia, Sub-Saharan Africa and Latin America, Hong and Mishra (2006), Uthman, Moarad and Lawoko (2009) and Hatt and Waters (2006) respectively used principal component analysis (PCA) to estimate wealth index from dwelling characteristics and asset variables that were significantly associated with per-capita expenditure. Instead of quintiles, (Van de Poel and Speybroeck 2009) used PCA to create "wealth thirds"—poorest, middle, richest—from a broad range of assets and living conditions but without including variables relating to water sources and toilet facilities.

This study used the wealth index included in the 2008 GDHS dataset as calculated by ORC Macro. This index was derived from a principal component analysis of household ownership of consumer items, ranging from a television set to a bicycle or car, as well as dwelling characteristics, such as source of drinking water, sanitation facilities, and type of flooring material (Rutstein and Johnson 2004). Consistent with majority of other studies, the wealth status of households and individuals in this study is characterized by wealth quintiles as follows: poorest, poor, middle, richer, richest. The richest category was used as the reference. Wealth index factor score (5 decimals) is another way to measure household wealth status but it was not used in this study because findings derived from it are somewhat difficult to interpret.

Water supply

Improved drinking water availability and accessibility can potentially benefit households in Ghana, particularly children, by minimizing their exposure to water-borne diseases like diarrhea, guinea worm, typhoid, cholera and dysentery which are common. As the 2008 GDHS reports, public taps are used by only 20% of rural households as the main source of drinking water. Regrettably only 10% of households treat their water before drinking (GSS, GHS, ICF Macro 2009).

While wells and boreholes constitute the major source of drinking water supply for rural households, Obiri (2007) reports from studying one mining community in the western region of Ghana that most of the water from boreholes dug out by mining companies are contaminated with heavy metals like iron (Fe), arsenic (As), zinc (Zn) and lead (Pb), exposing many communities and households, particularly children, to serious health risks. Other studies confirm this finding in mining communities in the Tarkwa mining area of Ghana (Asklund and Eldvall 2005). This study found that although metal concentrations were lower than expected in the study area, groundwater in some zones had heavy metal values that exceeded WHO guidelines.

In the 2008 GDHS data, source of water supply information for each dwelling unit was ascertained by the household questionnaire. The survey identified 14 drinking water sources but for the purposes of this study six main categories were created by combining related water sources as follows: 0 = piped water (water from pipe/tap, public tap), 1 = well water (includes tube well or borehole, protected and unprotected well), 2 = surface water (protected and unprotected spring, river/dam/lake/ponds/stream/canal/ irrigation channel), 3 = rainwater, 4 = other (tanker truck, cart with small tank, bottled water, sachet water, other). The first category was used as the reference against which the other categories were compared. Although a number of studies have used categories like safe, unsafe (Hong 2007; Hong, Banta and Kamau 2007), piped, not piped (Bomela 2009), this study believes that such simple categories miss the nuances in how different households access drinking water in Ghana.

Sanitation

Most experts agree that an improved toilet facility is the most efficient and hygienic way to dispose of human waste, but not many households have easy access to a toilet facility in Ghana. According to the 2008 GDHS report, only 11% of Ghanaian households use improved toilet facility and marked differences exist between rural and urban communities (GSS, GHS, ICF Macro 2009). Jenkins and Scott (2007) confirm this picture in a Ghanaian study that used the terms "adopters" and "non-adopters" to characterize households with toilet or latrine and those did not. They found out that more than half of all adults used public toilets while some 14% practiced open defecation. Also while children under 5 years overwhelmingly used potties, older children broadly reflected the toilet habits of their parents.

To examine household sanitation status and how it impacts child health and nutritional outcomes, this study used the 'type of toilet facility' variable in the 2008 GDHS data. This variable originally had 11 categories but for the purposes of this study four main categories were created by combining related categories as follows: 0 = flush toilet (flush to piped sewer system, flush to septic tank, flush to pit latrine, flush to somewhere else, flush, don't know where), 1 = no toilet (No facility/bush/field), 2 = pit latrine (Ventilated Improved Pit latrine (VIP), pit latrine with slab, pit latrine without slab/open pit), 3 = other (composting toilet, bucket/pan toilet, other). The first category was used as the reference against which the other categories were compared. There is no agreement in the literature about how to categorize this variable. While some including Hong (2006), Hong and Mishra (2006), and Hong and Ruiz-Beltran (2007) used 'yes' and 'no' categories to indicate presence and absence of toilet facility, other studies including Gyimah (2006) and Wichmann and Voyi (2006) categorized household toilet facilities as None, flush, Pit/KVIP, Bucket/pan. The categories used in this study allow for a more detailed analysis of sanitation beyond simple binaries.

Food safety

Although unhygienic practices in food preparation, contaminated water and waste disposal are often linked to diarrheal diseases, which are major causes of morbidity and mortality among Ghanaian children, the GDHS did not collect any data on the state of food safety in the country. Thus as important as this variable is to child health and nutritional outcome, this study excluded it from the analysis.

Links between Underlying Causes and Basic Causes

Education

The literature associates better child nutritional outcome with educated parents or caregivers because these adults are better able to plan their family, use health care facilities and ensure high environmental sanitation standards for their children. The 2008 GDHS reports a strong association between mother's education and lower fertility and higher contraceptive use in Ghana.

Ghana's educational system has changed a lot in the last two decade or so. The country now has a three-tier system made up of six years of primary education, three years of junior secondary school and another three years of senior secondary school. Pre-school is currently required as part of primary education and since 2006 the government has made all basic education free and implemented school feeding program to improve child nutritional outcomes. A four-year university education is the final step in this process but there are other post-secondary educational institutions that offer vocational, technical and professional training. Tertiary education has also been boosted by increased educational infrastructure funding.

Notwithstanding these changes and improvements, the 2008 GDHS reports that compared to 13% of men, some 21% of women have no education at all. Also while 28.8% of men have completed post-secondary education, the same can be said about only 17% of women. This picture is worse when rural/urban disparities are taken into account (GSS, GHS, and ICF Macro 2009).

To examine how parental educational status impacts child health and nutritional outcomes, this study used the “highest educational level” and “partner’s education level” variables to assess mother’s and father’s educational status respectively. In the 2008 GDHS data, parental education information was collected from the women and men questionnaires as part of surveying the background characteristics of respondents. The original categories (0 = No education, 1 = Primary, 2 = Secondary, 3 = Higher) created by the survey were utilized in this analysis for both mothers and fathers. The ‘no education’ category was used as the reference against which the other categories were compared. These categories were used because most studies (Andoh et al. 2007; Fotso 2007; Rajaram, Zottarelli and Sunil 2007) that analyzed the relationship between parental education and child health and nutrition use similar categories.

Employment

Respondents were also asked about the status of their employment for the 12 months preceding the survey. Assessing employment in Ghana is a difficult task because some types of employment like work on family farms and in the informal sector are often unreported. This has the potential to bias the data and subsequent analysis. The 2008 GDHS data overcame this possibility by asking respondents several probing questions about their work. Respondents who had worked in seven days or at any time in the 12 months preceding the survey were considered employed (GSS, GHS, ICF Macro 2009).

The variables used in this study to characterize parental employment were originally captured in the 2008 GDHS data as “Respondent’s occupation” for mothers and ‘Partner’s occupation for fathers, with ten categories. To assess how parental occupation impacts child health and nutritional outcomes, this study created four categories each for mother's and father's occupation by combining similar categories as follows: 0 = Not working (respondents who answered 'not working' and 'don't know' on the occupation question), 1 = Agricultural sector (respondents who answered 'agric-self-employed' and 'agric-employee'), 2 = Manual worker (respondents who answered 'skilled manual' and 'unskilled manual'), 3 = Other sector (respondents who answered 'Professional, Technical, Managerial; Clerical; Sales; Household and domestic; Services'). The 'not working' category was used as the reference in the analysis.

Other studies, including Chirwa and Ngalawa (2008) used categories like salaried employment, family business worker and self-employment to examine mother's occupation for the purpose of understanding economic empowerment. The categories used in this study are deemed to be appropriate for the setting and subject matter under consideration.

Statistical Analysis

The three most frequently used analytical techniques in nutritional studies to examine variables associated with child health and nutritional outcome are ordinary least squares (OLS) regression (see Balk et al. 2005; Morales, Aguilar and Calzadilla 2004; Shin 2007; Van de Poel et al. 2007), multilevel modeling (see Fotso 2007; Gyimah 2009; Heaton et al. 2005) and logistic regression (see Fotso and Kuate-Defo 2005; Frost, Forste, and Haas 2005; Hong 2007; Hong and Mishra 2006; Rajaram, Zottarelli, and Sunil 2007).

In Ethiopia, Umeta et al. (2003) used linear regression analysis to examine independent associations between supplementary food feeding variables and stunting. The study also used the Mann-Whitney test to assess group differences for data that were not normally distributed. Group means were compared by way of independent *t* tests. Likewise, Balk et al. (2005) used a simple ordinary least squares (OLS) regression analysis to test hypotheses from the UNICEF framework. All poorly performing and potentially endogenous variables were removed from the final equation models. In Bolivia, Morales, Aguilar and Calzadilla (2004) also applied ordinary least squares (OLS) to estimate each equation related to height and weight z-scores.

Multilevel models were, however, used by Fotso (2007) to examine differentials in child stunting by location of residence, and to investigate their socioeconomic correlates, while controlling for variables at different levels. In Bangladesh, Saha et al. (2008) also used multilevel models to model weight and length trajectories of infants and young children because of the longitudinal nature of the weight and length data. The study carried out two levels of analysis, with the first level describing how individual children had changed over time and the second level describing how these changes varied across children.

In Maharashtra (India), Bawdekar and Ladusingh (2008) also used the multilevel regression analysis technique to examine the contextual correlates of child malnutrition. District-level variables and household-level covariates were incorporated. Tengco et al. (2008) moreover used multilevel mixed-effects linear regression with village and household as random parameters as part of the analytical strategy to assess the determinants of anemia among preschoolers in the Philippines.

Logistic regression is however by far the most preferred statistical technique for analyzing the correlates of child nutritional outcomes. In Nigeria, Ukwuani and Suchindran (2003) used ordinal logistic regression (and also chi-square) to investigate how women's economic activity influenced stunting and wasting. Logistic regression procedures were also used by Bloss, Wainaina and Bailey (2004) to study the prevalence and predictors of underweight, stunting and wasting among under-5 children in Kenya; by Frost, Forste and Haas (2005) to estimate models linking maternal education and child nutritional status (treated as a dichotomous measure) in Bolivia; by Semba et al. (2008) to examine the relation between maternal and paternal education and other variables and the risk of child stunting in Indonesia and Bangladesh; and by Wamani et al. (2007) to compare the gender differences in stunting outcome for children in a study of ten Sub-Saharan African countries.

Also, Bronte-Tinkew and DeJong (2004) considered logistic regression models the appropriate statistical test for examining the association between household structure and economic resources on the one hand and child nutritional outcomes on the other (measured as dichotomous variables) in Jamaica. Similarly, logistic regression models were used in Bangladesh to estimate the regression parameters of chronic malnutrition among preschoolers in multivariate analysis (Rahman and Chowdhury 2007); in Libya and eastern Napal to determine both the odds and statistical significance of variables associated with stunting (Libya) and underweight and stunting (Napal) respectively (El Taguri et al. 2009; Singh et al. 2009); in Egypt to examine how parental and socioeconomic factors influence under-5 child stunting (Rajaram, Zottarelli and Sunil 2007); as well as in the three Central Asian Republics to examine the social, economic, health and environmental determinants of underweight and stunting (Bomela 2009) and in Cambodia and Ghana to estimate the effects of household economic status and other factors on stunting (Hong and Mishra 2006). Hong and Mishra (2006) also found that analysis with a continuous height-for-age response variable and a linear regression model yielded similar results.

The popularity of logistic regression is both the result of its numerous advantages and the disadvantages of the other competing techniques. For instance, OLS regression assumes that for all children in a sample, the outcomes are independent. This, however, ignores the fact that many household surveys employ cluster sampling, so that another hierarchy is always present in the data. DHS data in particular form a hierarchical structure with four levels (children nested within mothers, mothers nested within households, and households nested within sampling clusters). Since children of the same mother share familial characteristics such as quality of parental care, quality, availability, and distribution of food and sanitary conditions within the household, and are therefore exposed to the same physical and social environments at the household and cluster levels, there is a high chance for units from the same group to be more alike, making the assumption of independence of observations inherent in the conventional linear regression model hard to justify.

The consequence of ignoring hierarchical data structures and using a single-level model instead of a multilevel one is that standard errors and variance of the estimated coefficients are underestimated, making estimates of effects appear significant when in fact they are not (Bronte-Tinkew and DeJong 2004). Since OLS regression does not properly accommodate hierarchies in data, a number of studies examining child nutritional outcome have adjusted for correlations at the women's level or employed the multilevel modeling framework to account for potential model misspecification and possible clustering (see Bronte-Tinkew and DeJong 2004; Frost, Forste and Haas 2005; Moestue and Huttly 2008; Ukwuani and Suchindran 2003).

Acknowledging that some women contributed more than one child to the study sample in Nigeria, Ukwuani and Suchindran (2003) adjusted for correlation between observations at the woman's level to estimate the correct standard errors for the regression coefficients. Also, with 32% of children in their sample having at least one sibling, Frost, Forste and Haas (2005) adjusted for clustering at the mother level in all their models to correct the standard errors. In a Sub-Saharan African study, Fotso (2007) argued that the data analyzed had less than 1.3 children per household and therefore collapsed the child, mother and household levels to carry out two-level (child and community) random intercept logistic regression analyses. Moestue and Huttly (2008) also used a three-level model to account for the hierarchical structure in their samples from India and Vietnam. The first level dealt with measurements of the individual child and the child's household, while levels two and three dealt with measurements at the community and site respectively. Semba et al. (2008) avoided double counting by using the youngest child in a household as the index child for that household. The problem with this approach is that estimated values and coefficients might not represent the situation of older children.

Although multilevel modeling specifies both within level direct effects and between level interacting effects and therefore serves as a great technique for handling data where observations are not independent (Garson 2010), there are a number of drawbacks to using multilevel modeling. As Quene and van den Bergh (2004) point out, multilevel modeling is still largely an unfamiliar technique to many researchers but also suffers from computational complexity and opacity. Similarly, Diez-Roux (2000) observed that multilevel models are less parsimonious, require larger data sets and have complicated estimation procedures. She points to several warnings against "the rapid incorporation of complex multilevel models before their performance is adequately understood and evaluated, especially when it is done with little regard to the adequacy of the data and the inferences that can be drawn from it" (Diez-Roux 2000:186).

In light of the above, the advantage of logistic regression is that unlike OLS regression, it does not require variables to be normally distributed and assumes no homoscedasticity or linearity of the relationship between dependent and independent variables (Garson 2010; Pohlmann and Leitner 2003). It is therefore generally less stringent, making it easier to analyze dichotomous outcome variables and properly interpret results. Despite this flexibility, the logistic regression procedure is capable of modeling the odds of an outcome in terms of a vector of independent variables and an error term (Bronte-Tinkew and DeJong 2004). As Kleinbaum, Klein and Pryor (2010) observe, logistic regression is popular among social scientists because unlike other models, it is designed to provide estimates that must lie between 0 and 1. This insures that risk estimates are always a number between 0 and 1. But logistic regression is also popular, particularly among epidemiologists, because the S-shape of the logistic function is considered widely applicable to understanding the multivariate nature of a variety of disease conditions. Garson (2010) further notes that logistic regression transforms the dependent variable into a logit variable and applies maximum likelihood estimation to calculate the log odds instead of changes in the dependent itself as OLS regression does.

Given the strengths and weaknesses of the different analytical techniques discussed above, some studies have used a combination of techniques. Heaton et al. (2005) used logistic regression to evaluate the association between household-level variables and child health outcomes. Variables with no statistically significant relationships with the outcomes were eliminated before multilevel analyses to simplify the model. The study was however unable to estimate a model with random components for all covariates because of the relatively small number of the second level of observations. In Peru, (Shin 2007) applied OLS regressions to individual level variables to analyze differences in the effect of maternal education by region and a multilevel model to analyze community and regional effect on child health. However, since variance of error was inconsistent and depended on fixed covariates and the error term at the group level, two assumptions of standard regression were violated, resulting in biased OLS estimates.

In this study, data analyses were done using *SPSS 17.0* (SPSS Inc., Chicago, IL, USA) software for windows and *ArcMap version 9.3* (ESRI) and occasionally *Microsoft Excel 12.0*. The analyses included all children aged 0-59 months with valid anthropometric measures because while selecting one child per household would have eliminated the possibility of over-estimating parameter coefficients and the resulting model, there was also the real danger of substantially reducing the sample size for the analysis and the prospect of underestimating parameter coefficients and therefore the associated models. Furthermore, selecting one child per household creates the impression of an absence of competition among children for limited family resources. Including all children in the analysis, on the other hand, recognizes this aspect of children's lives and in many ways ensures that the research results reflect the real situation of children.

Like all DHS cluster sample design, the GDHS 2008 data has a hierarchical structure mainly due to randomly sampling naturally occurring groups in the population. It is noteworthy, however, that the data analyzed has an average of 1.6 under-five children per mother and 2.4 mothers of under-five children per household in the data. To account for the hierarchical structure of the data, a two-level multivariate logistic regression modeling approach was adopted. The first level collapsed child-mother- and household-level data and was labeled 'child level' and the second level is represented by the socioeconomic characteristics of the district in which children reside. Separate logistic regression models were constructed for each of the nutritional outcome variables at each of the levels specified.

Descriptive statistics were used to summarize the prevalence of stunting, underweight and hemoglobin and to obtain frequencies and proportions for selected independent variables at each level (see Hong 2007; Uthman 2009; Uthman, Moradi, and Lawoko 2009). Further statistical analyses were performed in two steps at the child level and three steps at the district level. In the first step at the child level, bivariate associations between selected child, individual and household characteristics and the three child nutritional outcomes (stunting, underweight and hemoglobin) were investigated using chi-squared (χ^2) tests to determine the statistical significance of these associations (see Singh et al. 2009). In the second step, all the significantly associated variables in the bivariate analysis were subjected to binary logistic regression analysis using the forward (conditional) method with significance test set at $p < 0.05$ level (two-tailed), to test the independent effects of these variables.

At the district level, descriptive statistics were first obtained for each selected variable. This was followed by analysis of the bivariate association between selected district variables and the three nutritional outcomes using binary logistic regression. Significantly associated variables were then assessed together in a binary logistic regression to test their independent effects using the forward (conditional) method with significance test set at $p < 0.05$ level (two-tailed). Three separate full models that controlled for the effects of both child-level and district-level variables were then estimated for each nutritional outcome variable using hierarchical binary logistic regression analysis and the forward (conditional) method. The results of fixed effects (measures of association) were indicated by odds ratios (ORs) with 95% confidence intervals (CIs).

Logistic regression is considered most appropriate for this study because of the dichotomous nature of the nutritional outcome variables used for the analysis. The logit equation for the study defined by log $[P/1 — P] = a + bX$, where $P/(1 — P)$ is the odds of the outcome given the independent measure X; and where a and b represent coefficients to be estimated (see Frost, Forste and Haas 2005). Thus, this equation and model coefficients express the log of the odds of a child being malnourished versus not as a function of the set of explanatory variables previously mentioned. Standard errors of the β coefficients were examined for multicollinearity.

Chapter 4

ANALYSIS OF CHILD, MOTHER AND HOUSEHOLD VARIABLES ASSOCIATED WITH CHILDREN'S NUTRITIONAL STATUS IN GHANA

Sample Characteristics

The height-for-age and weight-for-age of 2385 children and the hemoglobin of 2168 children were analyzed in this study as shown in Table 2. While about 23% of the children are stunted and 18.2% are underweight, a whopping four out of every five children or 80.1% are anemic.

Table 2: Nutritional outcomes for children under age 5 years in Ghana, 2008

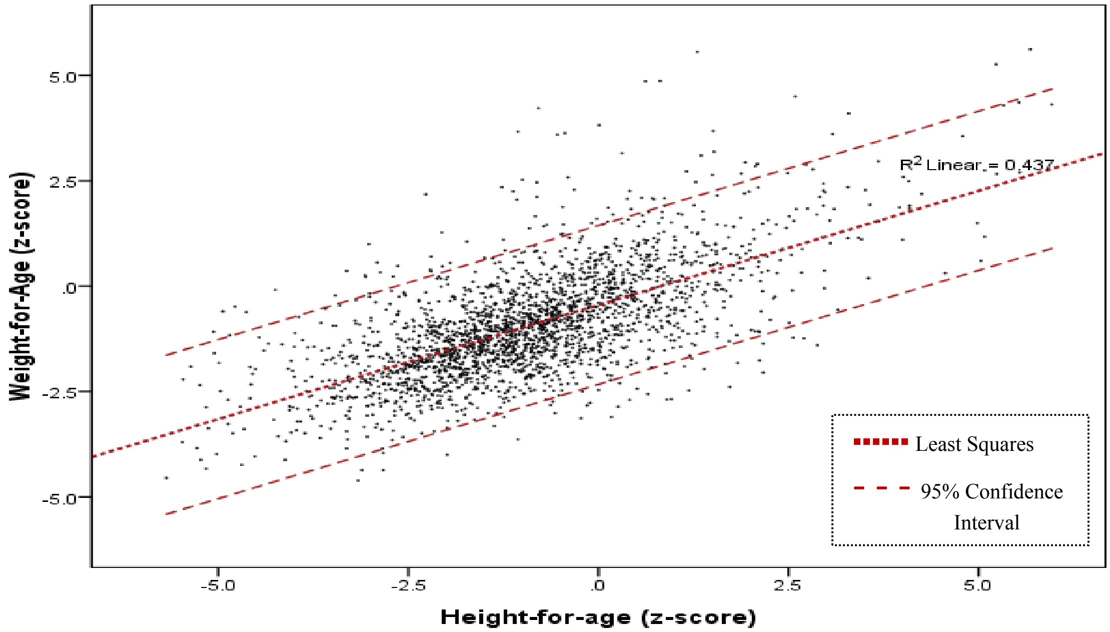
Nutritional outcome	**n**	**%**
Height-for-Age (z-score)	**2385**	
Not stunted (0)	1837	77.0
Stunted (1)	548	23.0
Weight-for-Age (z-score)	**2385**	
Not underweight (0)	1951	81.8
Underweight (1)	434	18.2
Hemoglobin (g/l)	**2168**	
Not anemic (0)	432	19.9
Anemic (1)	1736	80.1

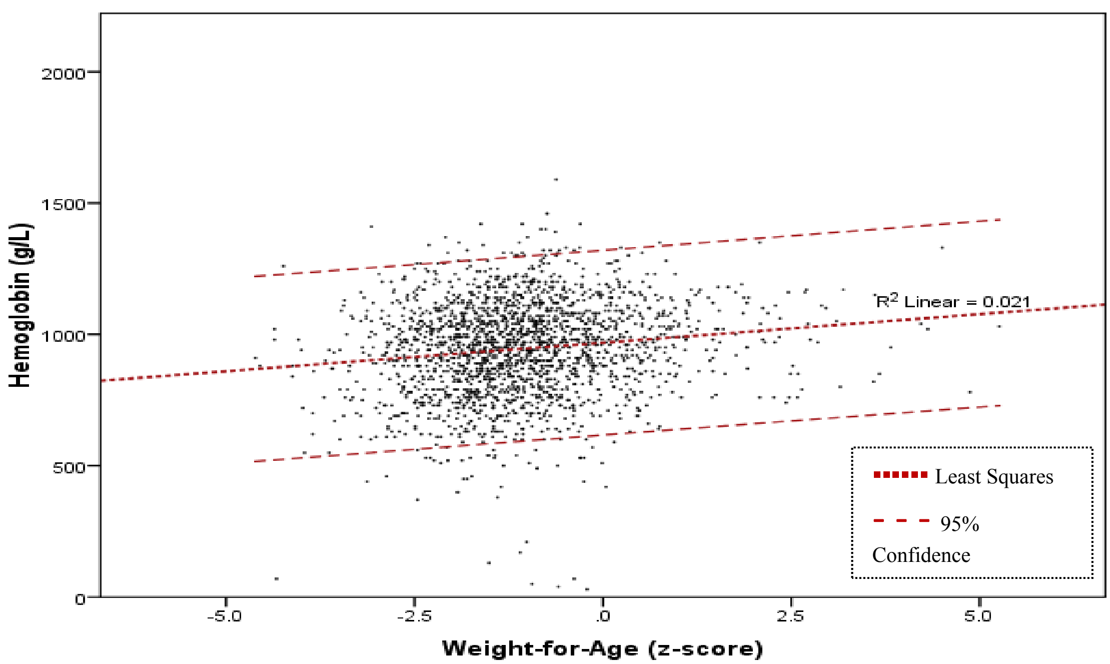
Data source: GSS, GHS, and ICF Macro 2008

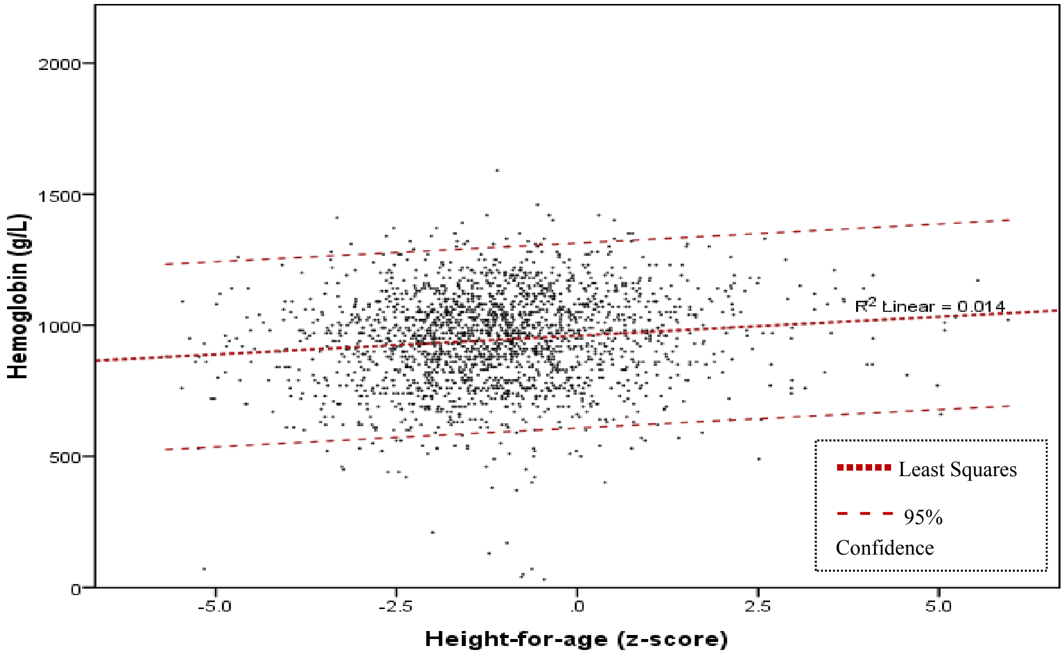
Relationship between outcome variables

The relationships between all three nutritional outcome variables were examined by generating scatterplots as shown in figure 3 below. The results show that while there are significant positive relationships between the outcome variables, the sizes of the correlation coefficients (R^2) are small and therefore indicative of very weak relationships. The implication is that even though the three outcome variables are related, they measure different aspects of children's nutritional status.

Figure 3: Scatterplots of child nutritional outcome variables in Ghana, 2008







Data source: GSS, GHS, and ICF Macro 2008

Child Characteristics

As table 3 shows, the children analyzed in this study are almost evenly divided by sex with boys making up 50.4% and girls 49.6%. Most children (37%) are in the 36 months or older age group and over 95% of all children are either fully or partially immunized for their age. The majority of children (79.2%) received 6-24 months of breastfeeding. Some 14% of the children received no vitamin A supplement and 21% experienced bouts of diarrhea and fever in the two weeks preceding the survey.

Compared to boys, girls fared slightly better on all three nutritional outcomes and the prevalence of stunting, underweight and anemia was higher among children in the 13-24 months age group. As other studies have shown, children in this age group are the most at risk because in most cases they have just been weaned from breast-milk but have not quite yet adjusted to the intake of solid foods. Interestingly fewer (72%) children age 36 months and older were anemic. Children who were small in size at birth are slightly less likely to be stunted (21.8%) and anemic (78.4%) but more likely to be underweight (18.7%) compared to children who were average or large size at birth.

Table 3: Prevalence of stunting, underweight and anemia among children aged 0-59 months by selected child, mother and household characteristics, Ghana 2008

Characteristic	N	% of children	% Stunted	% Underweight	% Anemic
Ghana	2380	100	23.0	18.2	80.1
Child					
Sex					
Female	1180	49.6	22.3	17.8	79.2
Male	1200	50.4	23.8	18.6	81.4
Child's age (months)					
0-12	530	22.3	6.0	11.7	87.0
13-24	516	21.7	29.8	28.1	87.5
25-36	454	19.1	24.0	20.5	82.5
>36	880	37.0	28.8	15.1	72.9
Size of child at birth					
Small	386	16.3	21.8	18.7	78.4
Average	658	27.8	23.3	18.4	81.7
Large	1321	55.9	23.4	18.1	80.2
Vaccination status					
Fully vaccinated	1656	69.6	22.8	18.8	79.4
Not vaccinated	106	4.5	17.9	11.3	86.2
Partially vaccinated	616	25.9	24.7	17.9	82.2
Months of breastfeeding					
Breastfed < 6 months	273	11.7	5.1	4.4	68.5
6 - 24 months	1852	79.2	24.0	19.0	80.2
> 24 months	214	9.1	35.5	27.6	83.0
Received Vitamin A					
No	339	14.3	19.8	13.3	84.2
Yes	2028	85.7	23.6	19.0	79.8
Had diarrhea recently					
No	1874	78.8	22.3	16.5	78.2
Yes, last two weeks	501	21.1	25.9	24.8	87.9
Had fever in last two weeks					
No	1875	78.9	22.5	17.4	78.7
Yes	499	21.0	24.8	21.2	86.2
Mother					
Mother's educational level					
No education	910	38.2	25.5	21.6	85.3
Primary	554	23.3	26.7	19.0	82.5
Secondary	863	36.3	19.0	14.8	74.3
Higher	50	2.1	8.0	6.0	66.7
Mother's occupation					
Not working	225	9.5	26.7	17.3	79.3
Agriculture sector	974	41.1	28.1	23.6	86.8
Manual work	200	8.4	17.5	16.0	77.5
Other	970	40.9	18.2	13.5	74.4
Marriage type					
Monogamous	1708	78.8	22.6	17.7	79.3
Polygamous	459	21.2	23.3	19.6	84.3

Mother's age at first birth					
<20 years	1194	50.2	25.6	20.1	82.9
20-30 years	1136	47.7	20.6	16.5	77.8
>30 years	50	2.1	16.0	10.0	73.8
Mother's BMI					
Underweight	176	7.5	29.5	27.3	85.5
Normal	1566	66.8	25.6	19.9	84.2
Overweight	451	19.2	16.0	12.4	70.6
Obese	153	6.5	9.2	6.5	61.4
Mother's health status					
Not Anemic	1427	61.1	23.3	17.8	76.6
Anemic	910	38.9	22.7	18.6	86.0
Prenatal care					
<3 visits	230	13.1	23.0	21.7	92.2
3-9 visits	1363	77.7	20.2	17.8	81.6
>10 visits	161	9.2	15.5	19.9	70.4
Birth in medical facility					
Public health facility	1094	46.1	20.1	14.5	75.6
Home/other	1100	46.3	26.5	22.2	86.1
Private health facility	181	7.6	18.8	16.6	73.0
Trained traditional attendant at birth					
No	1978	83.4	23.1	17.7	79.3
Yes	395	16.6	22.8	20.8	85.6
Health insurance					
No	1415	59.5	26.4	20.4	83.4
Yes	963	40.5	18.1	15.0	75.6
Household					
Sex of household head					
Male	1785	75.0	23.1	18.5	81.4
Female	595	25.0	22.7	17.3	77.2
Wealth index					
Poorest	782	32.9	27.7	24.2	87.9
Poorer	531	22.3	28.4	19.6	84.1
Middle	383	16.1	21.7	15.7	81.1
Richer	401	16.8	16.0	12.0	70.7
Richest	283	11.9	11.7	11.3	63.0
Ethnicity					
Akan	919	38.6	23.3	16.4	77.6
Ga/Dangme	109	4.6	18.3	18.3	72.4
Ewe	299	12.6	15.1	13.4	79.1
Mole-Dagbani	606	25.5	26.4	24.1	84.1
Other	445	18.7	24.3	17.1	83.4
Household size					
1-6	1581	66.4	22.0	18.0	79.4
7-10	634	26.6	24.9	18.3	82.1
>10	165	6.9	25.5	20.0	83.0
Number of children >5 years					
1	943	41.0	23.6	17.6	79.3
2	945	41.1	24.0	18.7	80.3
3+	411	17.9	18.5	17.8	83.2

Water supply					
Piped water	742	31.2	18.5	15.1	73.1
Well water	1138	47.8	25.9	20.5	84.7
Surface water	357	15.0	26.9	21.3	87.3
Other	142	6.0	14.1	8.5	61.4
Sanitation					
Flush toilet	164	6.9	12.2	10.4	58.8
No toilet	845	35.5	27.2	23.3	86.3
Pit latrine	1331	55.9	21.6	16.0	79.2
Other	37	1.6	21.6	10.8	75.9
Partner's educational level					
No education	796	35.0	26.7	22.5	85.9
Primary	206	9.1	28.2	23.3	88.9
Secondary	1100	48.4	20.8	15.5	76.7
Higher	170	7.5	16.5	10.0	68.1
Father's occupation					
Not working	10	0.4	10.0	10.0	77.8
Agriculture sector	1208	54.0	27.5	21.4	85.6
Manual work	400	17.9	19.3	16.0	76.2
Other	617	27.6	17.3	13.5	72.8
Husband lives in house					
Living with her	1685	78.4	22.8	18.4	81.8
Staying elsewhere	464	21.6	21.3	16.4	75.4
Migrant status					
Native	942	31.5	26.8	18.5	82.3
Migrant	2050	68.5	21.2	18.0	78.9
Type of migrant					
Urban native	245	8.2	19.7	11.4	70.5
Rural native	701	23.4	29.2	20.8	86.0
Rural-urban	494	16.5	16.4	17.7	72.2
Urban-rural	135	4.5	19.2	15.4	81.1
Urban-urban	261	8.7	12.9	9.4	60.5
Rural-rural	1156	38.6	25.3	20.5	85.5

Data source: GSS, GHS, and ICF Macro 2008

Another curious finding was that children who have received no vaccination for their age are less likely to be either stunted (17.9%) or underweight (11.3%) than their fully and partially vaccinated counterparts, but more likely (86%) to be anemic compared to children who received some form of vaccination for their age. There is also indication that breastfeeding confers a lot of nutritional advantages to children but extended breastfeeding is detrimental to children's nutritional well-being. While the prevalence of stunting (5.1%), underweight (4.4%) and anemia (68.5%) is lower among children breastfed up to six months, it increases dramatically for all the nutritional outcome measures with increased duration of breastfeeding. Extending breastfeeding over and above the recommended period of six months often indicates the inability of families to provide age appropriate solid food to children.

Children who received vitamin A supplement are also more likely to be stunted (23%) and underweight (19%) but less likely to be anemic (79%) than those who did not, and children who experienced episodes of diarrhea or fever in the two weeks preceding the survey were more likely than those who did not to be stunted, underweight and anemic.

Mother Characteristics

In terms of mother characteristics, the sample shows that while mothers of 36% of children have secondary education, only 2% of children have mothers with higher education and almost two out of five children were born to mothers with no education. The agricultural sector employs the mothers of a majority of children (41.1%) and 21.2% of children have mothers in polygamous marriages. About half of all children were born to young mothers (<20 years) and almost two out of five children have anemic mothers. Also, while 7.5% of children have underweight mothers, about a quarter have either overweight or obese mothers. Less than three prenatal care visits were made by the mothers of 13% of children but mothers of most children (77.7%) had three to nine prenatal care visits during pregnancy. Children are also almost equally split between being born in a public health facility and at home and very few births (16%) were attended by trained traditional birth attendants. The mothers of about two-thirds of children have no health insurance.

With the exception of stunting, the prevalence of nutritional deficit declined with increased maternal education. Children of mothers who worked in the agricultural sector were also more likely to have poorer nutritional outcome than children whose mothers had no work or engaged in manual and other work. Moreover children whose mothers are in polygamous marriages are slightly more likely to experience poorer nutritional well-being than their counterparts in monogamous households. All child nutritional outcomes also gradually improved as mother's age at first birth increased from under 20 years to more than 30 years of age and as BMI increased from underweight to obese.

The health status of mothers as measured by their anemia status had mix effect on nutritional outcome with children more likely to be stunted (23.3%) but less likely to be underweight (17.8%) and anemic (76.6%) if their mother was not anemic than if they were anemic. The nutritional status of children gradually improved across all measures with increased prenatal care visits by mothers. Children whose mothers had less than three prenatal care visits were more stunted (23%), underweight (21.7%) and anemic (92.2%) compared to children whose mothers had more than ten prenatal care visits (stunted, 15.5%; underweight, 19.9%; anemic, 70.4%). Furthermore, children born at home/other medical facility were more stunted (26.5%), underweight (22.2%) and anemic (86.1%) than children born in either public or private health facility. Likewise, children whose mothers had no health insurance were more stunted (26.4%), underweight (20.4%) and anemic (83.4%) compared to those whose mothers had insurance (stunted, 18.1%; underweight, 15%; anemic, 75.6%).

Household Characteristics

The characteristics of the household in which children live show that a quarter of all children are in female headed households and while about one-third of children live in the poorest households, only about 12% live in the richest households. Similarly, most children (38.6%) belong to the Akan ethnic group and only about 5% are members of the Ga/Dangme ethnic group. More children reside in households with 1-6 household members but about 7% of children belong to households with more than ten members and some 17.9% of children have more than three siblings under age five years. For almost half of all children (47.8%), wells are the major source of water supply and only 6.9% of children have access to flush toilet.

Furthermore, while about half of all children (48.4%) have fathers with secondary education, only 7.5% of children have fathers with higher education and some 35% of children have fathers with no education. As with mothers, the fathers of 54% of children are employed in agriculture but slightly less than 0.5% of children have non-working fathers. Also a little more than one-fifth of children have absent fathers. The use of mosquito bed net for malaria prevention was prevalent with about 75% of children living in households with bed net. Also, more children (68.5%) are from migrant families than native families and children of rural–rural migrants dominate.

Children's household characteristics are important to their nutritional well-being. Majority of children in male headed households are slightly more likely to be stunted (23.1%), underweight (18.5%) and anemic (81.4%) than their counterparts in female headed households. With the exception of stunting, nutritional status gradually improved with increased wealth. For instance, the percentage of underweight children declined from 24.2% among the poorest households to only 11.3% among the richest households and 87.9% of children in the poorest households were anemic compared to 63% of their counterparts in the richest households. In terms of ethnicity, children from the Mole-Dagbani ethnic group are more likely to be nutritionally deficient than children in any other ethnic group and children from larger households (>10 household members) were more prone to poorer nutritional outcome than children from households with up to six members.

There is however no clear advantages in having fewer children under age five in a household. Also children who had piped water or flush toilet in their households achieved better outcome on all nutritional measures than children who had access to only surface water or no toilet facility in their household. Increasing education of fathers also conferred greater advantages to children in all the nutritional categories except stunting where children of fathers with primary education performed worse. Surprisingly, children whose fathers are not working were not as stunted or underweight as children of working fathers, with children of working fathers in agriculture faring worse. Similarly, children of native residents were more stunted (26.8%) and anemic (82.3%) compared to children of migrants.

After disaggregating children by types of migrant household, children of urban to urban migrants were far better nourished and children of rural natives were the least nourished group with 29% being stunted, 20.8% underweight and 86% anemic. Children of rural-rural migrants followed closely with 25.3% stunting, 20.5% underweight and 85.5% anemic. Children of rural to urban migrants were also did better than rural natives and rural to rural migrants on all nutritional outcome measures and better than children of urban to rural migrants in terms of stunting and anemia.

Bivariate Analysis of Nutritional Outcomes and Child Level Variables

While the results above are interesting, they would be more sensible if the variables examined are significantly related to the nutritional outcomes under consideration. To achieve this, a bivariate analysis of selected demographic and socioeconomic characteristics of children, mothers and households was done to identify the factors that are significantly associated with stunting, underweight and anemia among children in Ghana as indicated in table 4 below. All three child nutritional outcome measures were found to be significantly associated ($p<0.05$) with the age of the child, months of breastfeeding, the educational level of the mother, mother's occupation, the age of mother at first birth, mother's BMI, birth in a medical facility, whether the child's mother has health insurance or not, the wealth status of the child's household, ethnicity, source of water supply, access to sanitation, the educational level of partner, father's occupation and the type of migrant household of a child. Diarrhea in the two weeks preceding the survey was however significantly associated with only underweight (χ^2 (2) =18.557, $p<0.05$) and anemia (χ^2 (2) =21.550, $p<0.05$).

Variables significantly associated with only one of the three nutritional outcome measures include Vitamin A supplementation, which was only significantly associated with child underweight (χ^2 (1) =6.469, p= 0.011), and migrant status, which was significantly associated with stunting (χ^2 (1) =8.910, p=0.003). Anemia on the other hand was significantly associated with fever in the two week preceding the survey (χ^2 (2) =18.557, p=0.002), marriage type (χ^2 (1) =4.945, p=0.026), mother's health status (χ^2 (1) =26.874, $p<0.05$), prenatal care (χ^2 (2) =25.105, $p<0.05$), trained traditional attendant at birth (χ^2 (1) =7.317, p=0.007), sex of household head (χ^2 (1) =4.162, p=0.041) and the presence of a husband in the household (χ^2 (1) =8.046, p=0.005).

Table 4: Bivariate relationship between nutritional outcome measures and child, mother and household variables in Ghana, 2008

Characteristic	**Stunting**		**Underweight**		**Anemic**	
	χ^2 (df)	**p**	**χ^2 (df)**	**p**	**χ^2 (df)**	**p**
Child						
Sex	0.717(1)	.397	.247(1)	.619	1.577(1)	.209
Child's age (months)	116.355(3)	.000*	56.263(3)	.000*	54.376(3)	.000*
Size of child at birth	0.461(2)	.794	.072(2)	.965	1.430(2)	.489
Vaccination status	2.563(2)	.278	3.791(2)	.150	3.296(2)	.192
Months of breastfeeding	69.512(2)	.000*	48.558(2)	.000*	5.662(2)	.059*
Received Vitamin A	2.433(1)	.119	6.469(1)	.011*	2.267(1)	.132
Had diarrhea recently	3.647(2)	.161	18.557(2)	.000*	21.550(2)	.000*
Had fever in last two weeks	1.248(1)	.264	4.384(2)	.112	12.736(2)	.002*
Mother						
Mother's educational level	21.610(3)	.000*	19.040(3)	.000*	35.606(3)	.000*
Mother's occupation	31.928(3)	.000*	34.247(3)	.000*	41.698(3)	.000*
Marriage type	0.104(1)	.747	.906(1)	.341	4.945(1)	.026*
Mother's age at first birth	9.731(2)	.008*	7.236(2)	.027*	9.476(2)	.009*
Mother's BMI	39.471(3)	.000*	37.032(3)	.000*	66.478(3)	.000*
Mother's health status	0.108(1)	.742	.223(1)	.637	26.874(1)	.000*
Prenatal care	3.338(2)	.188	2.207(2)	.332	25.105(2)	.000*
Birth in medical facility	14.789(2)	.001*	21.882(2)	.000*	38.791(2)	.000*
Trained traditional attendant at birth	0.013(1)	.908	2.005(1)	.157	7.317(1)	.007*
Health insurance	22.597(1)	.000*	11.240	.001*	19.159	.000*
Household						
Sex of household head	0.051(1)	.822	.415(1)	.519	4.162(1)	.041*
Wealth index	50.933(1)	.000*	40.547(4)	.000*	92.715(4)	.000*
Ethnicity	16.410(1)	.003*	21.105(4)	.000*	14.368(4)	.006*
Household size	2.752(2)	.253	.423(2)	.810	2.425(2)	.297
Number of children > 5 years	5.499(2)	.064	.442(2)	.802	2.302	.316
Water supply	23.509(3)	.000*	20.114(3)	.000*	68.037(3)	.000*
Sanitation	20.755(3)	.000*	27.347(3)	.000*	57.605(3)	.000*
Partner's educational level	15.855(4)	.003*	25.634(4)	.000*	41.202(4)	.000*
Father's occupation	28.857(3)	.000*	19.211(3)	.000*	40.704(3)	.000*
Husband lives in house	0.477(1)	.490	1.006(1)	.316	8.046(1)	.005*
Has mosquito bed net	2.293(2)	.318	1.283(2)	.527	2.639(2)	.267
Migrant status	8.910(1)	.003*	.089(1)	.766	3.507(1)	.061
Type of migrant	38.370(5)	.000*	22.939(5)	.000*	93.622(5)	.000*

Data source: GSS, GHS, and ICF Macro 2008

*significant at p<.05 level

A number of variables were found to have no significant bivariate relationship with any of the nutritional outcome measures. These include the sex of the child, size of the child at birth, vaccination status, the size of the household, the number of children age 5 years and under and whether the household has a mosquito bed net or not. These variables were therefore excluded from further analysis in the multivariate logistic regression models specified for each nutritional outcome variable below.

Multivariate Analysis of Child Level Variables and Nutritional Outcomes

Stunting model

To adjust for potentially confounding effects, all significantly associated variables from the bivariate analysis of stunting were simultaneously entered into a logistic regression analysis to generate a child level model for stunting in Ghana. Out of a total of sixteen variables entered, six variables including child's age, months of breastfeeding, mother's BMI, health insurance, wealth index and ethnicity were retained in the model. Table 5 shows the results of fixed effects reported with odds ratios (ORs) along with confidence intervals for $p<.05$.

As the β coefficients indicate, child level stunting is positively associated with the age of the child, months of breastfeeding and wealth index but negatively associated with mother's obesity, health insurance and ethnicity. While increasing values of the negatively associated variables results in lowering the odds of stunting among children, higher values of positively associated variables achieve the opposite effect of increasing the odds of stunting among children.

The age of a child remains a significant explanatory factor for stunting among children in Ghana, with children in the 13- to 24-month age group most likely to be stunted (1.579, $p<0.05$) compared with children in the referenced category (age 0-12 months). But children of other age groups are also significantly more likely to be stunted than the referenced age group. For instance, the odds of stunting among children in the 13- to 24-month age group is 4.8 times (95% CI: 3.058-7.688; $p<0.05$) that for children in the referenced category. For children in the 25- to 36-month age group and those in the 36 months or more age group, the odds of stunting are respectively 3.7 times (95% CI: 2.266-5.884; $p<0.05$) and 4.7 time (95% CI: 3.042-7.351; $p<0.05$) greater than the odds for children in the referenced group.

Table 5: Logistic regression model for stunting among children in Ghana

Variable	β	SE β	Wald's χ2	df	p	eβ (odds ratio)	95% CI for eβ	
							Lower	Upper
Constant	-3.607	.389	85.874	1	.000	.027		
Child's age (months)								
0-12*			52.103	3	.000			
13-24	1.579	.235	45.061	1	.000	4.849	3.058	7.688
25-36	1.295	.243	28.318	1	.000	3.652	2.266	5.884
>36	1.554	.225	47.635	1	.000	4.729	3.042	7.351
Months of breastfeeding								
Breastfed < 6 months*			12.705	2	.002			
6 —24 months	.891	.315	7.991	1	.005	2.437	1.314	4.518
> 24 months	1.244	.352	12.474	1	.000	3.469	1.739	6.918
Mother's BMI								
Underweight*			7.691	3	.053			
Normal	.045	.192	.054	1	.816	1.046	.718	1.523
Overweight	-.288	.164	3.064	1	.080	.750	.544	1.035
Obese	-.723	.307	5.546	1	.019	.485	.266	.886
Health insurance								
Yes	-.365	.117	9.732	1	.002	.694	.552	.873
Wealth index								
Richest*			20.433	4	.000			
Poorest	.741	.241	9.476	1	.002	2.099	1.309	3.364
Poorer	.844	.238	12.631	1	.000	2.326	1.460	3.706
Middle	.380	.250	2.316	1	.128	1.463	.896	2.387
Richer	.247	.251	.963	1	.326	1.280	.782	2.094
Family ethnicity								
Akan*			9.669	4	.046			
Ga/Dangme	-.102	.289	.125	1	.724	.903	.512	1.591
Ewe	-.612	.199	9.424	1	.002	.542	.367	.801
Mole-Dagbani	-.076	.154	.244	1	.621	.927	.686	1.253
Other	-.124	.163	.584	1	.445	.883	.642	1.215

Test	χ2	df	p
Model fit test			
Omnibus	219.463	17	0.000
Hosmer- Lemeshow	7.322	8	0.502

Note. Cox and Snell R^2 = .098. Nagelkerke R^2 (Max rescaled R^2) = .148. -2 Log likelihood = 2087.634. Overall percentage predicted= 77%. All statistics reported here use 3 decimal places in order to maintain statistical precision.

Data source: GSS, GHS, and ICF Macro 2008

*Reference group

There is also a positive effect of breastfeeding duration on stunting, with the odds of stunting being 2.4 times (95% CI: 1.314-4.518; p=0.005) and 3.5 times (95% CI: 1.739-6.918; p<0.05) higher in children breastfed 6-24 months and more than 24 months respectively compared to those breastfed less than 6 months. Also, compared to children of underweight mothers, the odds of stunting is significantly decreased by a factor of 0.5 (95% CI: 0.266-0.886; p=0.019) among children of obese mothers, and children whose mothers have health insurance have their odds of stunting decreased by a factor of 0.7 (95% CI: 0.552-0.873; p=0.002) compared to children whose mothers have no health insurance.

In terms of household wealth, the study results found stunting to be significantly associated with the poorest and poorer wealth quintiles, with children in the poorer wealth quintile more likely to be stunting compared to children in the richest wealth quintile. For instance, the odds of stunting is increased 2.3 time (95% CI: 1. 604-3.706; p<0.05) among children in the poorer wealth quintile and 2.1 times (95% CI: 1.309-3.364; p=0.002) among children in the poorest wealth quintile compared to children in the richest wealth quintile. Membership in all the categories of family ethnicity considered also decreased the odds of stunting in children relative to the referenced ethnic group (Akan) but only membership in the Ewe ethnic group achieved significance. The odds of stunting among children from Ewe households were decreased by a factor of 0.5 (95% CI: 0.367-0.801; p=0.002) compared to children from Akan households (reference group).

In light of these findings, the child level stunting model with significantly associated variables can be specified as follows:

Predicted logit of (stunting) = -3.607 + 1.579*child's age (13-24 months) + 1.295*child's age (25-36 months) + 1.554*child's age (>36 months) + 0.891* breastfed (6-24 months) + 1.244*breastfed (>24 months) —0.723*mother's BMI (obese) —0.365*health insurance (yes) + 0.741*wealth index (poorest) + 0.844*wealth index (poorer) —0.612*ethnicity (Ewe)

Overall, this model adequately fits the data as the Hosmer-Lemeshow goodness of fit shows (χ^2 = 7.322(8); p=0.502) and correctly predicts 77% of child stunting in Ghana. It indicates that child level stunting is significantly associated with children's age over 12 months, being breastfed for more than six months, having an obese mother and a mother with health insurance, belonging to the poorer and poorest households and being a member of the Ewe ethnic group.

Figure 4: Graph of odds ratios for stunting among children in Ghana

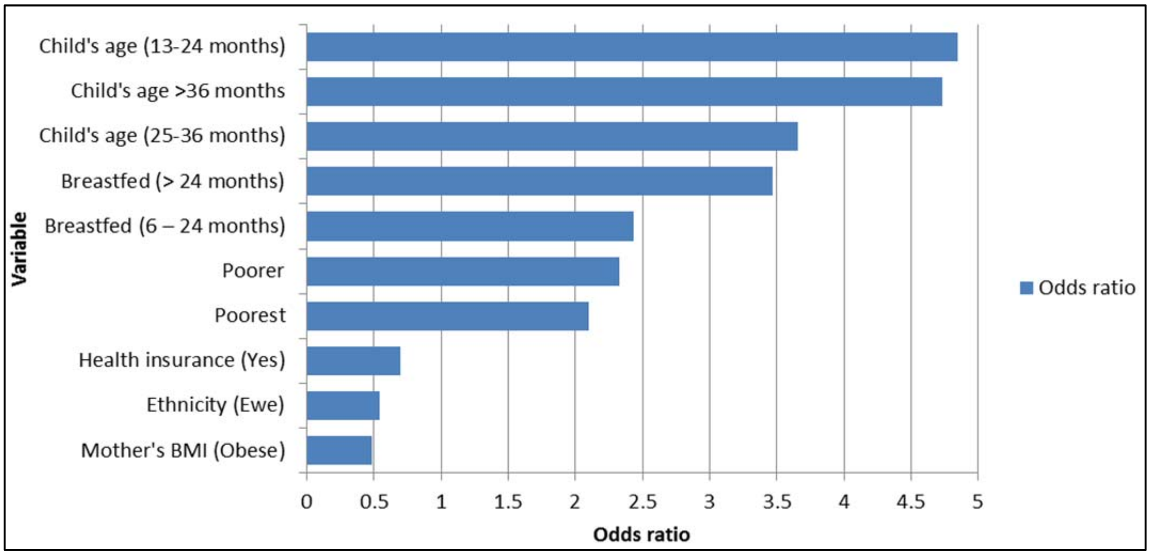


Figure 4 above shows the graph of odds ratio of the significantly associated variables. Odds ratio below 1.0 have the greater effect of reducing the odds of stunting, controlling for all other variables in the model (Garson 2010). Thus obese mothers have the greatest effect in reducing stunting among children in Ghana. Other factors that effectively reduce the odds of stunting among children are membership in the Ewe ethnicity and if a child's mother has health insurance. The remaining significantly associated variables have odds ratio above 1.0 and therefore increase the odds of child stunting, with children's age 13-24 months increasing the odds of stunting the most or having the least effect in reducing stunting among children in Ghana.

Underweight model

For the underweight model, seventeen variables with significant bivariate relationship to underweight were entered into the logistic regression. Four variables including child's age, months of breastfeeding, and mother's occupation and BMI were retained in the model as shown in table 6.

Table 6: Logistic regression model for underweight among children in Ghana

Variable	β	SE β	Wald's χ2	df	p	eβ (odds ratio)	95% CI for eβ	
							Lower	Upper
Constant	-2.785	.344	65.554	1	.000	.062		
Child's age (months)								
0-12*			36.649	3	.000			
13-24	.717	.195	13.504	1	.000	2.049	1.397	3.003
25-36	.170	.211	.652	1	.419	1.185	.785	1.791
>36	-.182	.195	.867	1	.352	.834	.569	1.223
Months of breastfeeding								
Breastfed < 6 months*			26.248	2	.000			
6 —24 months	1.175	.315	13.911	1	.000	3.239	1.747	6.007
> 24 months	1.803	.360	25.017	1	.000	6.067	2.993	12.297
Mother's occupation								
Not working*			19.112	3	.000			
Agriculture sector	.282	.216	1.698	1	.193	1.326	.867	2.027
Manual worker	-.192	.286	.452	1	.502	.825	.472	1.445
Other	-.293	.226	1.677	1	.195	.746	.479	1.162
Mother's BMI								
Underweight*			11.922	3	.008			
Normal	.295	.198	2.231	1	.135	1.343	.912	1.979
Overweight	-.296	.171	2.995	1	.084	.744	.532	1.040
Obese	-.870	.342	6.473	1	.011	.419	.214	.819
Test					**χ2**	**df**		**p**
Model fit test								
Omnibus					132.797	11		0.000
Hosmer- Lemeshow					9.147	8		0.330

Note. Cox and Snell R^2 = .060. Nagelkerke R^2 (Max rescaled R^2) = .099. -2 Log likelihood = 1879.539. Overall percentage predicted= 82%. All statistics reported here use 3 decimal places in order to maintain statistical precision.

Data source: GSS, GHS, and ICF Macro 2008

*Reference group

Although mother's occupation was retained in the model, none of the categories showed significant association with child underweight at the p<0.05 significance level. Child age 13-24 months, all the categories of breastfeeding duration and the obese category of mother's BMI were however significantly associated with child underweight. In particular, the odds of underweight among children aged 13-24 months are about twice

(95% CI: 1.397-3.003; $p<0.05$) the odds of underweight among children age 0-12 months (reference group).

Breastfeeding duration had the most effect in increasing the odds of child underweight with increased duration resulting in increased odds of underweight among children. For instance, while the odds of underweight among children breastfed for more than 24 months is about six times (95% CI: 2.993-12.297; $p<0.05$) the underweight among the referenced age group, the odds of underweight among children age 6-24 months is 3.2 times (95% CI: 1.747-6.007; $p<0.05$). The only factor that reduces the odds of underweight among children in Ghana is having an obese mother. The odds of underweight among children with obese mothers were reduced by a factor of 0.42 (95% CI: 0.214-0.819; p=0.011) compared to children in the referenced age group.

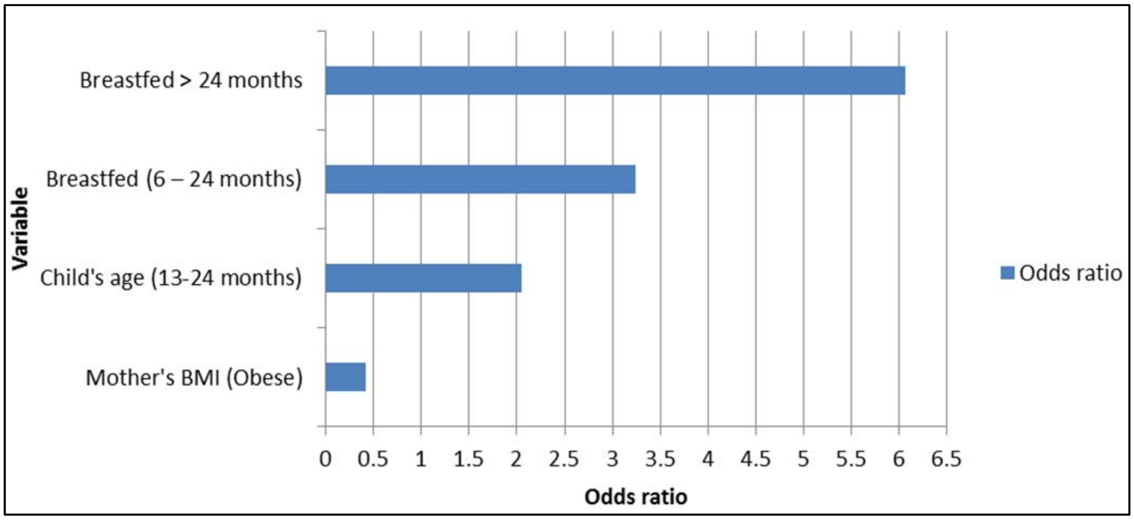
In light of these results, the child level underweight model for the significantly associated variables is specified as follows:

Predicted logit of (underweight) = -2.785 + 0.717*child's age (13-24 months) + 1.175* breastfed (6-24 months) + 1.803*breastfed (>24 months) —0.870*mother's BMI (obese)

As the non-significance of the Hosmer-Lemeshow goodness of fit ($\chi^2 = 9.147(8)$; p=0.330) shows, this model adequately fits the data. The model also correctly predicts about 82% of underweight among children in Ghana and indicates that the odds of childhood underweight is decreased by having an obese mother, but being a child age 13 -24 months and being breastfed for more than six months increases the likelihood of underweight among children.

The graph of odds ratio of significantly associated variables in figure 5 further confirms that obese mothers have the greatest odds of underweight conditions among children in Ghana and breastfeeding children for more than 24 months increases their odds of underweight the most, controlling for all other factors.

Figure 5: Graph of odds ratios for underweight among children in Ghana



Anemia model

Twenty-three significantly associated variables from the bivariate analysis were entered into logistic regression to generate the child level anemia model. Overall, six variables including child's age, having fever in the last two weeks preceding the survey, mother's health status (as indicated by anemia status), prenatal care visits, wealth index and water supply were retained for the model as shown in table 7.

Among the variables retained, the odds of anemia among children older than 36 months were reduced by a factor of about 0.5 (95% CI: 0.297-0.711; $p<0.05$) compared to children in the referenced age group. Unlike stunting and underweight, children in the 13 —24 month age group were not at a significant risk of suffering anemic conditions in Ghana. However, suffering from a recent episode of fever increases a child's odds of being anemic by a factor of 1.8 (95% CI: 1.221-2.702; $p=0.003$) compared to the odds of anemia among children who experienced no fever during the same time period.

If a child's mother is anemic, his or her odds of being anemic are increased by as much as twice (95% CI: 1.417-2.795; $p<0.05$) the odds of anemia in children whose mothers are not anemic. Surprisingly, the odds of anemia among children whose mothers had 3 to 9 prenatal care visits increased by a factor of 2.3 relative to the odds of anemia among the referenced group (less than three prenatal care visits).

Table 7: Logistic regression model for anemia among children in Ghana

Variable	β	SE β	Wald's χ2	df	p	eβ (odds ratio)	95% CI for eβ	
							Lower	Upper
Constant	.767	.271	7.992	1	.005	2.154		
Child's age (months)								
0-12*			31.601	3	.000			
13-24	.304	.240	1.598	1	.206	1.355	.846	2.169
25-36	-.109	.251	.189	1	.664	.897	.548	1.466
>36	-.778	.223	12.147	1	.000	.459	.297	.711
Fever in last two weeks								
Yes	.597	.203	8.668	1	.003	1.816	1.221	2.702
Mother's health status								
Anemic	.688	.173	15.792	1	.000	1.990	1.417	2.795
Prenatal care								
<3 visits*			10.270	2	.006			
3-9 visits	.834	.324	6.650	1	.010	2.304	1.222	4.344
>10 visits	-.401	.234	2.937	1	.087	.670	.424	1.059
Wealth index								
Richest*			11.933	4	.018			
Poorest	.904	.323	7.836	1	.005	2.470	1.311	4.653
Poorer	.592	.293	4.086	1	.043	1.807	1.018	3.208
Middle	.407	.282	2.089	1	.148	1.503	.865	2.611
Richer	-.006	.247	.001	1	.982	.994	.612	1.614
Water supply								
Piped water*			9.520	3	.023			
Well water	.352	.211	2.786	1	.095	1.422	.940	2.150
Surface water	.208	.306	.463	1	.496	1.231	.676	2.241
Other	-.645	.285	5.105	1	.024	.525	.300	.918

Test	χ2	df	p
Model fit test			
Omnibus	145.350	14	0.000
Hosmer-Lemeshow	3.645	8	0.888

Note. Cox and Snell R^2 = .107. Nagelkerke R^2 (Max rescaled R^2) = .176. -2 Log likelihood = 1063.235. Overall percentage predicted= 82%. All statistics reported here use 3 decimal places in order to maintain statistical precision.

Data source: GDHS 2008

*Reference group

Living in the poorest and poorer households also increased the odds of children's anemia by 2.5 (95% CI: 1.311-4.344; p=0.005) and 1.8 (95% CI: 1.018-3.208; p=0.043) times respectively compared to the odds of anemia among children living in the richest households. The only other factor that significantly reduced the odds of anemia among children in Ghana is the "other" category of water supply. As indicated in chapter 3 above, the other category of water supply is made up of sources such as tanker truck, cart with small tank, bottled water, sachet water and others. The study results show that the odds of anemia among children with "other" water supply source is reduced by a factor of 0.5(95% CI: 1.311 —4.344; p=0.005) compared to the odds of anemia among the referenced group.

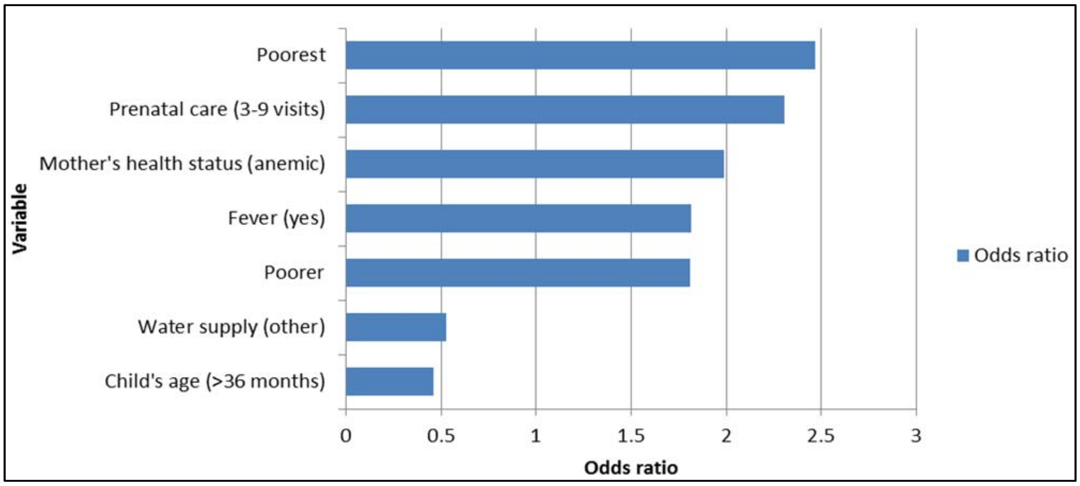
The following is therefore a model representation of anemia among children in Ghana:

Predicted logit of (anemia) = 0.767 —0.778* child's age (>36 months) + 0.597* fever (yes) + 0.688*mother's health (anemic) + 0.834*prenatal care (3-9 visits) + 0.904* poorest + 0.592*poorer —0.645*water supply (other)

This model fits the data as the non-significance of the Hosmer-Lemeshow goodness of fit test indicates (χ^2 = 0.645(8); p=0.888) and correctly predicts 82% of overall anemia among children in Ghana. The model shows that while being older than 36 months and having access to other water supply sources significantly decreases the odds of anemia among children, recent episodes of fever, having an anemic mother and a mother who had 3 —9 prenatal visits, as well as living in the two lowest wealth quintile households significantly increases the odds of anemia among children in Ghana.

The graph below shows all the significantly associated variables with the greatest effect in reducing or increasing the odds of anemia among children in Ghana. Clearly, child's age (> 36 months) emerges as the factor with the most effect in reducing the odds of anemia among children in Ghana. But using 'other' water supply sources is also effective in reducing the odds of anemia. The factor that increases the odds of anemia the most among children in Ghana is residence in the poorest household.

Figure 6: Graph of odds ratios for anemia among children in Ghana



Discussion

The results presented above point to a couple of factors that significantly impact nutritional well-being at the child level in Ghana. On the one hand, being a child aged 13—36 months, receiving six or more months of breastfeeding, living in a poor household and having an anemic mother significantly increase the chance of nutritional deficit among children. On the other hand, having an obese mother, a mother with health insurance, using "other" sources of water supply, being older than 36 month of age and belonging to the Ewe ethnic group significantly reduce the likelihood of children suffering nutritional deficits.

Although anemic conditions among children has received very little attention in the literature and in Ghana in particular, this study shows that it is the most important nutrition related problem confronting children in Ghana and most likely many other developing countries. As the study shows, anemia is exacerbated by poverty, anemia among mothers, fever and surprisingly 3 —9 visits for prenatal care during pregnancy. On the bright side, 'other' sources of water supply and children growing past their third birthday help reduce the odds of anemic conditions. The importance of 'other' sources of water supply in reducing the incidence of anemia among children in Ghana is evidenced by the fact that only 31% of children have access to piped water compared to over 62% of children who use either well water or surface water. As noted in chapter three, the ‘other’ water supply source is of similar quality as piped water but does not require expensive infrastructure for its distribution. It is therefore not surprising that children with access to this source of water supply are less likely to be anemic. The implication for stakeholders is that access to ‘other’ water supply sources should be maximized while efforts are being made to expand the more expensive and traditional means of supplying piped water to all communities in Ghana. Like previous studies on Ghana by Hong (2007) and Van de Poel et al. (2007), this study found no significant relationship between access to safe water supply and either stunting or underweight in Ghana.

Furthermore, it was observed that anemic conditions among children have some connections to anemia among adults. Children of anemic mothers were almost twice as likely to be anemic compared to children whose mothers were not anemic. Understanding this connection is very important for lowering the odds of anemia among children. A longitudinal study of Swedish children found the hemoglobin of well-nourished children was significantly associated with mother’s hemoglobin but the study could not explain the underlying mechanism for this occurrence (Ohlund et al. 2008). Olney et al. (2009) on the other hand found in a study of Zanzibar that children with higher densities of malaria parasite had significantly lower hemoglobin. In a multivariate analysis, Ehrhardt et al. (2006) also observed in northern Ghana that anemia was among other things associated with malaria infection. The high prevalence of malaria in Ghana could therefore explain the connection between anemic mothers and anemia among children. In Ghana most mothers live with their children in the same community, meaning that if the community is malaria infested, both mother and child would suffer similar lower hemoglobin.

Although the age of a child is generally associated with nutritional outcome as other studies have shown, children age 13 —24 months stood out as an important factor increasing the odds of both stunting and underweight in children in Ghana. In a study of child nutritional status in three Central Asian Republics, Bomela 2009 also found that compared to children older than age 24 months, children age 12 —24 months were 1.57 times more likely to be malnourished. This is however not very surprising because as the literature shows, children in this age group are typically transitioning from exclusive breastfeeding or breastfeeding with supplements to more solid foods. Given the high rate of poverty in the country and the tendency of caregivers to feed their children street foods, Colecraft et al. (2004) recommends educating caregivers about the safest street foods as well as enhancing the nutritional quality of these foods. It is therefore safe to assume that while most mothers are educated about breastfeeding, very little is done by way of education to help mothers decide the best and affordable foods to feed their children during the transitional period. In light of the finding in this study and others, it is important for stakeholders to educate mothers and other caregivers on how to handle the whole child nutrition transition experience to help improve nutritional outcomes.

In line with the above, this study also affirms what is already known about the detrimental effects of excessive breastfeeding on nutritional outcomes for children. In a study of rural Nigeria, Uthman (2009) noted that the odds of stunting among children increased by 4% for each additional month of breastfeeding. Thus while the high rate of breastfeeding in Ghana should normally lead to better child nutritional outcomes, the sad fact is that it appears a lot of mothers are not complementing the breast milk with appropriate foods after six months and/or fail to introduce children to solid and nutritious foods after 13 months. This means that most children are not adequately fed for their age and therefore do not receive proper nourishment as they grow. A probable cause of this could be that mothers lack the resources to secure the necessary nutrients for their children (Uthman 2009). Van de Poel et al. (2007) suggest however that some children are also more reluctant to each other foods and therefore leave their mothers with fewer options than to extend breastfeeding.

Poverty was significantly associated with stunting and anemia in this study, but surprisingly not with underweight in the multivariate analysis. It ought to be mentioned here that some have questioned the direct connection between child nutritional deficiencies and food scarcity or lack of family economic resources. Wachs (2008) for instance points to mediating and moderating influences from cultural and maternal input into family economic decisions and social support networks as critical. Still, overwhelming studies (see Bryce et al. 2008; Heltberg 2009; Khatib and Elmadfa 2009) suggest that children from poor households are more susceptible to poorer living conditions in terms of inadequate food intake, greater exposure to infectious diseases and lack of access to basic health facilities. The finding in this study, like previous ones (see Assis et al. 2007; Hong 2007; Sanchez-Perez et al. 2007) indicate that children from poor households are more at risk of stunting and anemia compared to children from more wealthy households.

Obese mothers were also important for reducing the odds of both stunting and underweight among children in Ghana. This is interesting because at first glance, it seems like a bad thing for a mother to be obese, given the health and other sociocultural implications of obesity in most developed countries. However, in many developing countries where poverty plagues most societies, obesity among mothers could indicate that those mothers have access to more than enough resources for themselves and their children. Indeed, a separate cross tabulation analysis not shown here indicates that compared to other mothers, obese mothers in Ghana are better educated, have skilled jobs, live in wealthier households, have fewer children with diarrhea, are in monogamous marriage, have their first births in the 20 —30 years age group, have fewer home births, more health insurance coverage and have better educated partners who are employed in high skilled job. All these factors seem to position obese mothers and their children to have better nutritional outcome compared to other children. This finding is confirmed by three other studies in Nigeria, Bangladesh and India by Uthman (2009), Rahman and Chowdhury (2007) and Dharmalingam, Navaneetham and Krishnakumar (2010) respectively. Uthman (2009) for instance found mother's BMI to be negatively and significantly associated with stunting in a study of rural Nigeria. The study suggested that children in households where mother had low BMI were more likely to be stunted.

Surprisingly, although mother's education was significantly associated with all three child nutritional outcomes in bivariate analyses, it lost its significance in the multivariate analyses. This outcome is however consistent with a previous study on Ghana by Hong (2007). He found that mother's education lost its significance after controlling for other factors in multivariate analysis and suggested that this may be due, in part, to a large majority of mothers in Ghana having only primary or no education. This study found that more than 61% of mothers had either no education or only primary education. Also surprising but not unusual was the fact that sanitation and parental occupation did not show significant association with any of the nutritional outcomes examined. Similar conclusions were reached on Ghana by Van de Poel et al. (2007) and Hong (2007). This might therefore be a place specific finding.

Notwithstanding the discussion above, it is well acknowledged that the nutritional outcome of children is greatly influenced by the overall socioeconomic and biophysical environment in which they live. In recognition of this fact, this study also analyzed selected district socioeconomic variables and biophysical characteristics of the places where children reside, while controlling for the influence of the child level variables discussed above. The findings from these analyses are presented in chapters five and six below.

Chapter 5

DISTRICT VARIABLES ASSOCIATED WITH CHILDREN'S NUTRITIONAL OUTCOMES IN GHANA

Recent fascination with the influence of context on children's health and nutritional outcome derives from the desire by researchers to understand how individual outcomes and behaviors are influenced by factors beyond the household level (see Fotso and Kuate-Defo 2006; Ladusingh and Singh 2006; Moestue and Huttly 2008). Bawdekar and Ladusingh (2008) observe that a healthy environment contributes about 20% in child malnourishment reduction in many developing countries. In India, they found that community-level variables like community education and hygiene played an important role in reducing the risk of under-5 child deaths. Fotso and Kuate-Defo (2006) likewise report that contextual effects were better at accounting for community clustering of childhood malnutrition in Africa than likely compositional effects. Particularly, environmental and geographical factors have been found to affect infant and child survival in important ways in Sub-Saharan Africa where large sections of the population are highly vulnerable to fluctuations in food and water availability, infectious and water-borne diseases, macro-environmental factors (including climate and rainfall), and soil fertility (Kazembe, Muula and Simoonga 2009; Mason et al. 2005).

A number of studies have considered geographical location as an explanatory factor for large regional variations in childhood health and nutrition in many developing countries. In Nigeria, Kandala et al. (2007) investigated the effect of geographical factors and other important risk factors on morbidity among young children in two different years and found higher prevalence of childhood diarrhea, cough, and fever in northern and eastern states compared to western and southern states. Also children from urban areas had significantly lower risk of fever than their rural counterparts. The study suggested climatic change, the Sahelian drought and environmental pollution from oil extraction activities in the Niger Delta as partially responsible for the observed outcomes. Moreover, in Malawi, Kazembe, Muula and Simoonga (2009) found the highest prevalence of fever in the central and southern regions compared to the northern region.

The central region also had the highest prevalence of diarrhea even though there was no clear clustering of the disease. Children in rural communities were highly associated with both fever and diarrhea prevalence than urban children. The study suggests that both fever and diarrhea are influenced by environmental factors including climatic ones.

By its nature context and the factors that account for it depend on the place of interest, but generally most nutritional studies include availability and accessibility of public health and other basic services (particularly water and sanitation) (Cuesta 2007; Johnson, Padmadas and Brown 2009) , community education and literacy status (Kravdal 2008; Ladusingh and Singh 2006; Moestue and Huttly 2008), biophysical environment (including biomes, soil, vegetation, temperature) (Bawdekar and Ladusingh 2008) and economic considerations (especially poverty status) (Fotso and Kuate-Defo (2006). In Mexico, the contextual variables examined included proportion of educated women, proportion of under-5 measles vaccination, proportion of households without access to sewage systems, and proportion of households with a dirt floor (Sepulveda et al. 2006). Morales, Aguilar and Calzadilla (2004) included geography (represented by altitude) and culture (represented by language) as contextual variables in their analysis of child malnutrition in Bolivia, and in India, Bawdekar and Ladusingh (2008) examined how topography, development and literacy impact severe child malnutrition.

In this study, ecological zones (treated in chapter 6), population density, poverty index (p0), district-level wealth quintile, literacy, water and sanitation access, proximity to health and school facilities, residence status and urbanization were used to examine the effects of context on child health and nutrition outcome in Ghana. The importance of this analysis is captured by the fact that while a lot of studies (Asante and Zwi 2009; Johnson, Padmadas and Brown 2009; Owusu, Agyei-Mensah, and Lund 2008) have examined various contextual variables in Ghana, they have dealt with only one or two variables at a time and very few have linked such variables to children’s nutritional outcomes (Gyimah 2006; Hong 2007).

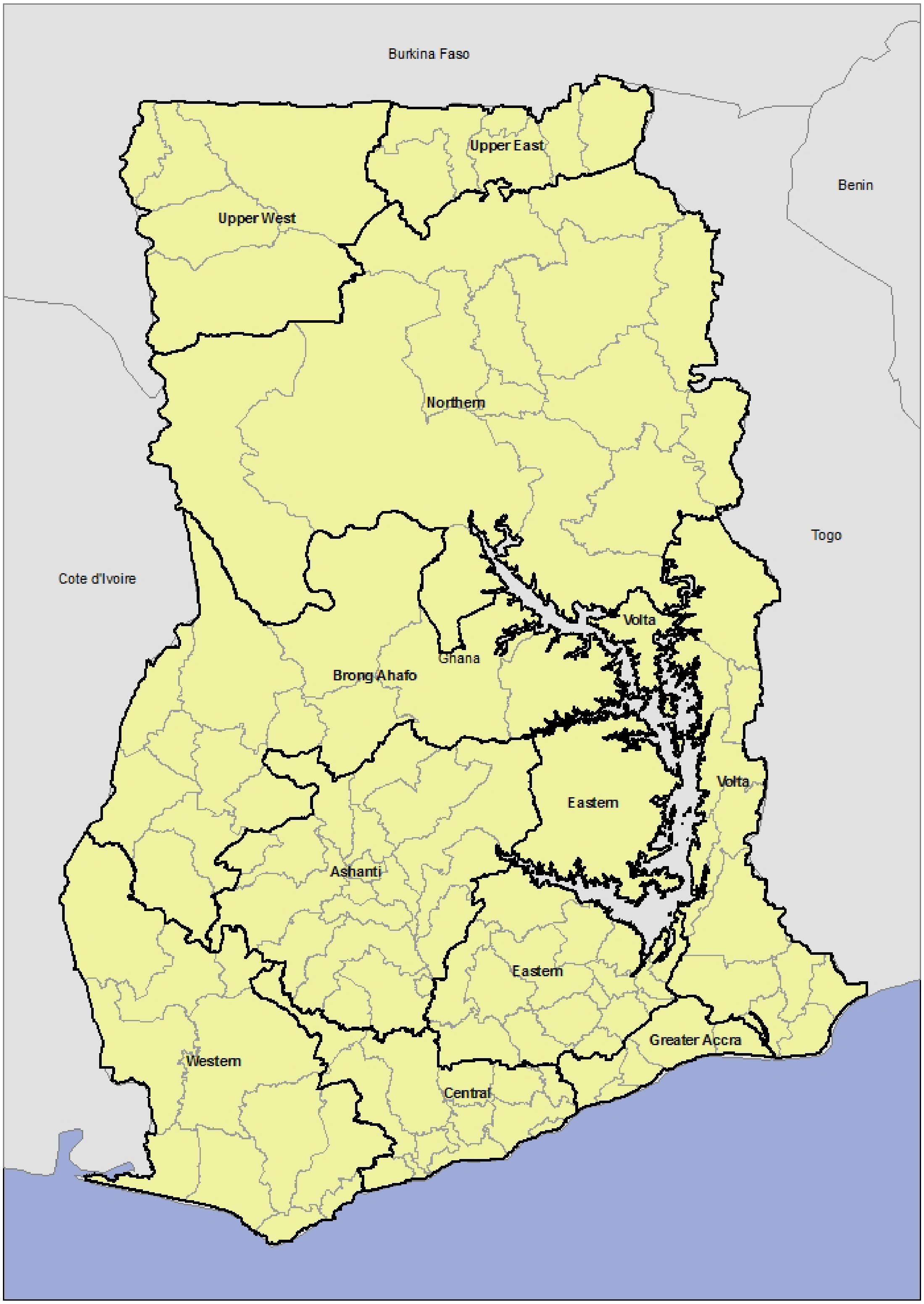
Administrative Units in Ghana

Ghana is situated on the Gulf of Guinea in West Africa and covers about 92,100 sq. mi, roughly the combined size of Illinois and Indiana. Ghana's neighbors, all francophone, include Côte d'Ivoire, Togo and Burkina Faso to the west, east and north respectively. The country is currently divided into ten (10) administrative regions and 138[3] districts to insure effective administration at regional and local levels (figure 7). Prior to the current system, the country had a highly centralized administrative structure, which limited the involvement of local communities in decision making. The implementation of decentralization policies in 1988, created a four-tiered system of local government based on population size and level of socioeconomic development. At the top is the Regional Coordinating Council (RCC), followed by Metropolitan, Municipal and District Assemblies, then the Urban/Town/Area Councils and unit committees at the bottom (Dery and Dorway 2007). The most important component of this administrative system, the District Assemblies, was designed to have the highest political and administrative authority, with deliberative, executive, and legislative powers in each district.

They are also responsible for creating lower tiers of administration like town or area councils and unit committees, within their sphere of influence (Koranteng and Larbi 2008; Owusu 2009). In all, 110 administrative districts were carved out of the existing sixty-five districts, and relabeled District Assemblies instead of District Councils. The number of administrative districts within each region varies, with the Ashanti Region having the most (eighteen districts), and the Greater Accra Region and the Upper West Region having the fewest (five districts), even though Greater Accra hosts the capital. Each region is headed by a regional minister and each district assembly by a district chief executive, all appointed by the president.

[3] Although there are 138 districts in Ghana, 110 districts were used in this study because the 28 newly created districts have little to no useful data for analysis in this study.

Figure 7: Administrative boundaries in Ghana



Data source: Ghana Statistical Service 2005

Although decentralization allows more participation of people at the grass-roots level in decision-making that affects them, Koranteng and Larbi (2008) argue that the policy has not worked as it should because of "intra- and inter-group network of interests". They point to increased concentration of power and resources in key sector Ministries, Departments and Agencies as evidence that key actors in the process have been competing rather than cooperating, and have consequently undermined their capacity to manage the implementation of the decentralization policy. Notwithstanding, given the importance of district assemblies in the political and administrative process in Ghana, this study used districts as the basis for analyzing the effects of context on children's nutritional outcome in Ghana.

Socioeconomic Characteristics

At independence in 1957, Ghana was hailed as one of the most promising African countries because of its "open" economy and vast natural and human resources. However, optimism was replaced by uncertainty in the decades that followed as Ghana faced inflationary crises and Gross National Product (GNP) declined (Johnson, Rutstein, and Govindasamy 2005). Persistent reliance on the export of a few primary products with little or no value added (cocoa, gold, timber and others) exacerbated these problems.

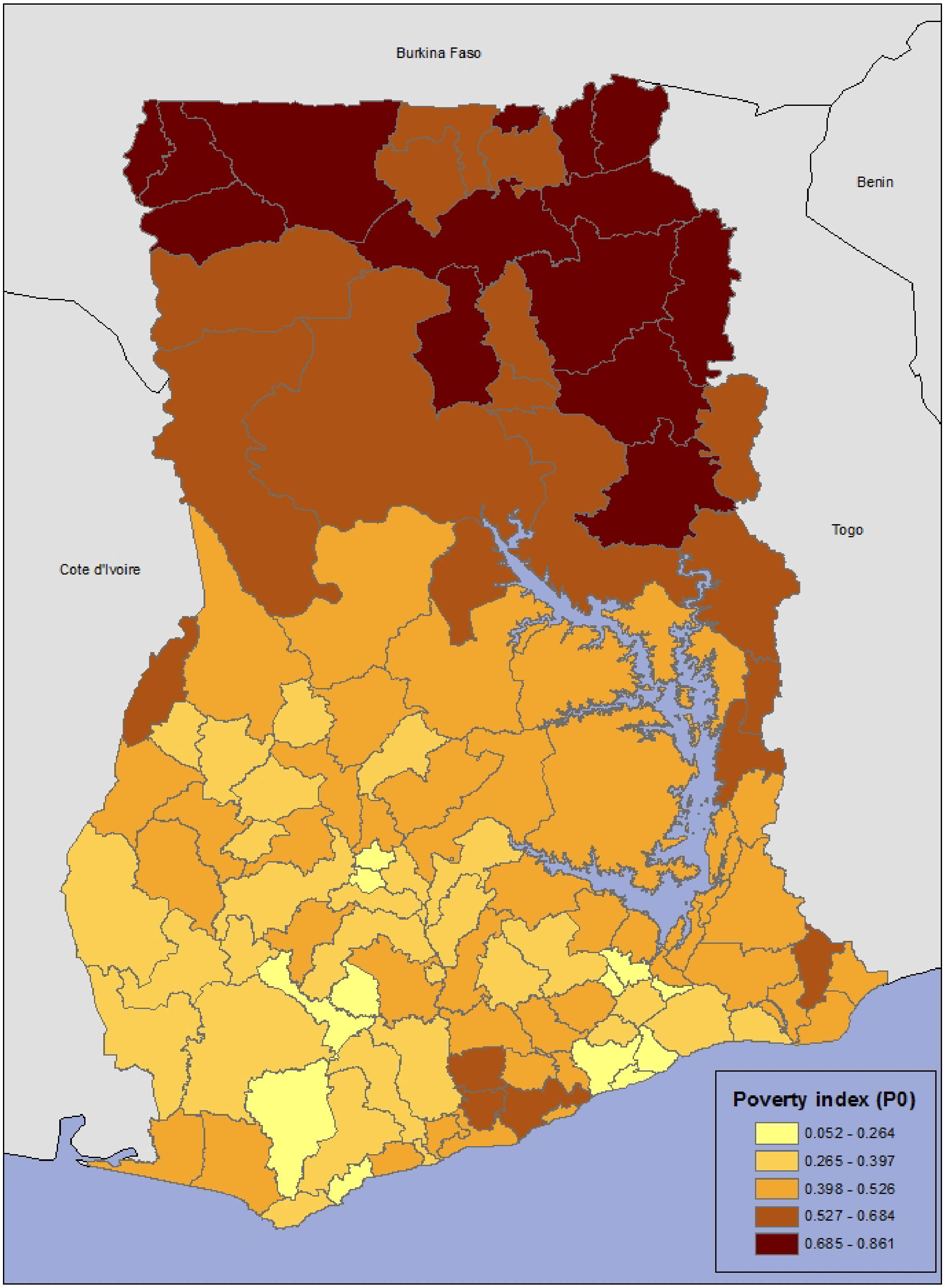
In 1983, the Rawlings government adopted the Economic Recovery Program (ERP) sponsored by the IMF/World Bank. Its goal was monetary stabilization in the short term and long-term economic liberalization and growth. While some observers argue that Structural Adjustment Programs (SAPs), which were introduced as part of the ERP, have contributed to economic growth and strengthened national economies, others decry the programs' failure to address the social, human, and environmental and equity dimensions in Africa. Aryeetey-Attoh (1997, 256) points out that economic growth in Ghana in the 1980s came at the cost of "currency devaluations and strict credit restrictions" that adversely affected farmers (who could not afford the high cost of agricultural inputs), and women and children. This observation is confirmed by the Ghana Poverty Reduction Strategy (GPRS) which noted that extensive liberalization and adjustment in the 1980s produced some growth in the service and mining sectors but did little to produce and sustain growth in the agriculture and manufacturing sectors. As a result both growth and incomes remained stagnant in the 1990s and produced less than acceptable levels of poverty reduction (GPRS 2003).

Since the implementation of the economic recovery program in the 1990s, Ghana has benefitted from debt relief under the Heavily Indebted Poor Countries (HIPC) initiative, G-8 debt relief program and the Millennium Challenge Corporation (MCC) funding. The result is that although the country's total debt grew from U.S. $5.5 billion in 2000 to an estimated $7.2 billion in 2002; by 2009 the estimated total debt had declined to $5.84 billion. And while the domestic economy continues to revolve around subsistence agriculture, recent GDP growth has been driven by strong performance of cocoa and gold exports. Accelerated economic growth is also supported by good performance in the mining sector, high public sector expenditure, and strong public and private sector investment activity (FAO 2009).

Poverty

Essentially, poverty indicates a state of need and the inability to utilize opportunities and one's potential to obtain the necessities of life. Poverty statistics in Ghana show that forty-five percent of Ghanaians live on less than U.S. $1 per day (UNICEF 2006a) and that while the highest fifth of households receive nearly half of all income, the poorest two-fifths receive only 16% of the total income (GSS et al. 2007; UNICEF 2006a). A number of studies observe that five out of 10 regions in Ghana have more than 40% of their population living in poverty, especially those in the poorly developed rural areas of the northern regions (Johnson, Padmadas and Brown 2009; Konadu-Agyemang 2000). Indeed, figure 8 confirms that the districts in the northern parts of Ghana, with headcount index (P_0) of poverty ranging from 0.527 to 0.861, experience the most extreme levels of poverty in Ghana. These indexes mean that between 53% and 86% of the population in these areas is poor. The districts in the southern and western parts of the country, however, tend to be less poor. This pattern of north-south contrast, with living standards highest in Greater Accra, holds for such measures as whether households have electricity, piped water, and telephones.

Figure 8: Headcount poverty index by district in Ghana



Data source: Coulombe, 2005

Broad generalizations aside, poverty in Ghana is mostly a rural phenomenon even though a few urban enclaves are also affected. For instance, while only 11% of the urban population was below the national poverty line in 2005-2006, almost 40% of the population in rural areas fell below the poverty line (ECOWAS and UN Statistics Division 2008; GSS 2007). Rural poverty is often related to both poor people possessing fewer individual resources and rural place poverty. Important elements of the latter relate to remoteness of location and therefore low integration into the wider economy. In some relatively poor parts of rural Ghana the importance of physical distance to health care facilities, especially modern health services cannot be overemphasized. Remoteness and lack of adequate transportation have severe public health implications for vulnerable groups like mothers and children, particularly in situations of acute health problems.

In a recent analysis of poverty in Ghana, Jorgensen (2008) examined connections between poverty, health and geography and noted that although female poverty is not usually depicted in most statistics, there were indications that it has grown in magnitude and pose grave consequences for mother and child health and nutrition in the country. This, in spite of Ghana achieving average annual gross domestic product growth rates of 6.2 percent in 2006 and significantly reducing the national rate of undernourishment to 13 percent in 2002 (WFP 2005, IMF 2009). The implication is that improvements in national wealth did not effectively trickle down to the poorest segments of society.

A case in point is the increasing differentiation between GAMA (made up of Accra, Tema and Ga Districts) as a command, gateway and service center, on the one hand, and on the other, regions relegated to the margins of global capitalism and national development (Konadu-Agyemang 2001). But even within the GAMA, the World Bank (1998, 43) notes that 'against a general trend of economic recovery and growth, the decline in living standards in Accra is a major source of concern'. This is because despite the globalization of aspects of the Accra economy, poverty levels in the city appear to have tripled during the liberalization era (Konadu-Agyemang 2000).

These inequalities have resulted in increasing malnutrition among children under-five years, deteriorating environmental standards, growing informalization of jobs (especially hawking), relative depravation, decreasing access to health care, social exclusion, and declining nutritional diets, all of which are well documented for particular groups in Accra (Kwesi Owusu and Kuttunen 2005).

Education/illiteracy

Education is a key element in the overall strategy for reducing child malnutrition in developing countries but Moestue and Huttly (2008) observes that while mother's education has been well established to impact child nutritional outcome in developing countries, the direct and indirect influence of the education of other individuals in the mother's community in determining child nutrition remain less explored.

The need to explore the role of other community member in reducing childhood malnutrition is made even more important as many mothers join the workforce and leave their children for long hours with other household members or neighbors. In India and Vietnam, Moestue and Huttly (2008) found that although the effect of community-level maternal literacy was diminished after adjusting for non-education confounders and independent risk factors, it remained statistically significant for both height-for-age and weight-for-age. After accounting for parental education, however, community-level maternal literacy achieved borderline significance for height-for-age but not for weight-for-age. In a different study in southern India, Moestue et al. (2007) concluded that among the poor, better child nutrition was associated with the size and literacy of a mother's social network. Bawdekar and Ladusingh (2008) also used the percentage of literate females to examine educational status of communities at the district level in India and found an inverse but significant association between the percentage of literate females (and also road length) and severe child malnutrition. What all these studies suggest is that in many developing countries the health and nutrition of children may benefit from increased community literacy.

Despite the best efforts of this study to locate research on community education and child health and nutrition in Ghana, nothing was found on the subject. The 2008 GDHS report however indicates that school attendance in Ghana is higher in urban than rural areas, among males than females in all the regions, and in the southern regions than the three northern regions. These patterns are also reflected in the prevalence of literacy and illiteracy among different groups across the country. These factors could potentially impact children's nutritional outcome.

In this study, district-level maternal literacy was measured by the proportion of literate mothers in the district. The choice of a district-level literacy variable over education variable was based on the assumption that literacy is the key outcome of education.

Health care

Accessibility to maternal health care services, availability and affordability of skilled care at birth and the quality of delivery care services determine birth outcomes and maternal health. Despite progress in maternal and child survival in recent decades, problems continue to exist particularly in developing countries where the health-care system is still struggling to provide basic public health services (Hong 2006). In many instances, while adequate healthcare services for managing high risk pregnancies and delivery are available at regional and national hospitals, for many poor rural dwellers access to these facilities is constrained by distance, cost of transportation and medical fees among many others barriers. Examining district, village and household level characteristics that influences malnutrition in rural Maharashtra in India, Bawdekar and Ladusingh (2008) concluded that village road connectivity is very important for enhancing the availability and accessibility of health facilities. But health facilities staffed with adequate personnel, particularly pediatricians, at both the district and village level have to be put in place first, if extreme health conditions and malnutrition are to be identified and treated in a timely fashion.

Spatial inequalities defined by uneven distribution of resources across different locations are of particular concern in Ghana, where more than 50% of births take place at home under the supervision of unskilled birth attendants and in unhygienic surroundings (Johnson, Padmadas and Brown 2009). In particular, the time required to reach a health facility could affect the chances of survival of sick children and their mothers, especially in emergency situations. Yet, only 57.6% of Ghanaians lived within 30 minutes of a health facility in 2003 (FAO 2009). Vast rural-urban disparities also exist with more than three quarters (78.5%) of urban households compared to only 27% of the rural poor living within 30 minutes of a health facility (Ghana Statistical Service 2005). Marked differences also exist among regions in terms of health insurance coverage with 35% of the population in the Brong Ahafo region registered or covered compared to only 5% of the population in the Upper West region (FAO 2009).

The main causes of death among children under five in Ghana include malaria (33%), neonatal causes (28%), pneumonia (15%) and diarrheal diseases (12%) (UNICEF 2006; WHO, 2006), which are all associated with poverty. As a leading cause of morbidity and mortality, malaria is a major public health concern, especially among young children and pregnant women in Ghana (GSS et al. 2007). But equally importantly, about 40% of all child deaths beyond infancy have been linked to protein-energy malnutrition (PEM), making it the greatest single cause of child mortality (Government of Ghana/UNICEF 2000) and ranking Ghana in the medium to high range of malnutrition severity (UNICEF 2006a). To this end, implementation of the Ghana School Feeding Program (GSFP) is an important step towards reducing malnutrition among school-age children.

Water and sanitation

In many communities in developing countries water is a scarce commodity, available only in limited quantities for consumption, hygiene, and cleaning. Contaminated water and food are major causes of malnutrition and mortality among children and remain a major public health and nutrition concern in many developing countries (Marino 2007; Rao et al. 2007).

A number of studies show that community-based piped water provision and flush toilets have the greatest potential to reduce malnutrition. Household access to point source water and latrines are more likely to reduce the probability of birth malnutrition among poor households than other public infrastructure (Cuesta 2007). In a study of child nutrition determinants in Malawi, Chirwa and Ngalawa (2008) found that community level water sources had mixed effects on nutritional status of children under five years.

The presence of a well, whether protected or not, encouraged wasting among children. However, at 10% significance level, unprotected wells were surprisingly found to be significantly associated with improved height-for-age among children. Tap water was similarly found to be significantly and positively associated with height-for-age at the 5% level.

In two Philippines municipalities, Tengco et al. (2008) report that water supply was mostly from communal taps or piped-in supply and had a significantly independent effect on hemoglobin (Hb) concentration, with the highest Hb levels among Barili residents whose water supply was either the river or a private well. A rather paradoxical finding from the study is that children from households (mostly more scattered) in the municipality of Dalapuete who use spring or rain water for drinking or cooking have better Hb and zinc protoporphyrin (ZPP) concentrations than those from households with water from a well or piped-in system. Spring water from Barili was however more likely to be contaminated because of the close proximity of houses to the source of water.

The government of Ghana was solely responsible for water supply and sanitation in Ghana until the early 1990s when a new policy aimed at ensuring sustainability of these services shifted focus to greater community self-reliance, particularly in rural and small towns. Private sector participation in the operation and management of water and sanitation utilities in urban areas increased as a result. In rural areas, the policy led to community ownership and management of water and sanitation facilities. A somewhat surprising consequence of these policy changes is that in recent years water supply coverage trends have reversed for rural and urban communities even though urban populations continue to enjoy greater access to safe water. For instance, while rural water supply coverage increased from 41% in 2000 to 52% in 2006, urban water supply coverage declined from 76% in 1990 to 60% in 2002 (Awuah, Nyarko and Owusu 2009), mostly as a result of rapid urban population growth outstripping water infrastructure investment in urban areas.

Examining the performance of the water and sanitation sector in both rural and urban communities in Ghana, Awuah, Nyarko and Owusu (2009) observed poor performance of the Ghana Water Company despite its claim of about 60% coverage. The company lost about 50% of its water output through "un-accounted-for water". The rural water supply coverage of 53% was also achieved by way of boreholes, hand-dug wells, and small-piped systems. In Accra, the capital city of Ghana, acute shortage of water has resulted in widespread rationing by the Ghana Water Company. While about 25% of residents receive a 24hour water supply, about 30% have 12 hours supply for five days and 35% have only 2 days of water supply. Ten percent of residents, usually on the outskirts of Accra, are completely without access to piped water and rely on independent sources of supply, paying up to 14 times more than those connected to the Water Company. Moreover, while 95% of rural residents depend on ground water supply, this source is contaminated by high levels of metals in the south part of the country and high levels of fluoride compounds in the north, posing the greatest threat to health (Awuah, Nyarko and Owusu 2009).

Microbial contamination of domestic drinking water both at its source and at home has been recognized as another problem for households. In a study that examined the determinants of community and household water quality in six coastal districts in Ghana's Central region, McGarvey et al. (2008) reports that about three quarters of households have > 2 E. coli /100 ml H2O. Tap water have significantly lower E. coli levels compared with surface or rainwater and well water which has the highest levels of E. coli. The study further reveals that households with a water closet toilet have significantly lower exposure to E coli compared to those that use pit latrines or have no toilets. The study concludes that variations in community and household socio-demographic and behavioral factors are key determinants of drinking water quality and argued for these factors to be included in health education planning associated with water systems investments.

Sanitation remains the more problematic issue in Ghana with most wastewater treatment in urban areas occurring at the household level and involving septic tanks and soakaways. Nationally, 55% of households have safe sanitation even though urban (80.9%) and rural (33.1%) disparities exist. But worse still, only 9.2% of the rural poor have access to safe sanitation facilities compared to 66.9% of their urban counterparts (Awuah, Nyarko and Owusu 2009). In most urban areas the inability to pay for this service is the major reason for its limited provision. Poor individual and community hygienic practices coupled with insufficient and ineffective hygiene education means that diseases are widespread in many rural communities than urban ones. Indeed, guinea worm, a parasitic infection largely attributable to drinking unsafe water, continues to plague Ghana, which had the second largest number of cases in 2007 (Mitani 2007).

Migration

A number of studies show that while rural-urban migrants have higher survival prospects compared to those they leave at home, they are still disadvantaged compare to their urban non-migrants. This means that while migrants gain through migration to urban areas, they remain vulnerable when compared to the native population in the destination areas.

By far, rural-urban migration is the most significant factor causing faster growth of populations in urban centers. Islam and Azad (2008) note that because of their lower income levels, rural-urban migrant women are more likely than urban natives to live in a dwelling that lack basic amenities like electricity, piped drinking water or flush toilet. The study also indicates that narrowing of rural-urban health disparities may be partly due to the higher risk of mortality among children of poor urban migrants. As other studies note, the rapid growth in cities is making maintenance, much less improvement, of rates of vaccination and school attendance a major challenge in urban Ghana (Fotso 2007).

In the year 2000, about one in four Ghanaians migrated domestically, with about 10% migrating within their region of birth and about 17% engaging in inter-regional migration. The Greater Accra and Western regions host the highest number of the in-migrant population, mostly from other parts of southern Ghana. The Ashanti and Brong Ahafo regions are two other regions that attract a lot of migrants but mostly from the three northern regions, especially the Upper East and Upper West regions (Van der Geest, Vrieling and Dietz 2010). By far, Accra is the largest recipient of domestic migrants in Ghana. In the year 2000, more than 1.1 million inhabitants of the Greater Accra region were born outside the region (Ghana Statistical Service 2005). The regions closest to Accra including Eastern, Volta, Central and Ashanti supplied the largest number of these migrants. Although rural to urban migration is mostly blamed for Accra's urbanization, statistics actually show that the vast majority of migrants in Accra previously lived in other urban centers (Ghana Statistical Service 2005). While employment and the prospects of wealth is a major draw, it is very expensive to live in the city and therefore very few poor rural people are able to successfully migrate to Accra.

Several studies (see Anarfi et al. 2003; Sabates-Wheeler, Sabates, and Castaldo 2008; Van der Geest, Vrieling and Dietz 2010), mostly focused on rural to urban migration, detail a wide range of individual, household, community and natural factors that cause migration in Ghana. These include high population growth rate, which has generally increased the domestic supply of labor and pressured cultivable land in source regions. Other factors are environmental push factors, and urban-biased policies, which have contributed to the widening of rural-urban income differentials, as well as social conditions. Most studies however point to economic factors as the fuel for rural-urban migration in Ghana.

Migration has important implications for the livelihoods of both migrants and the people who stay behind and it is increasingly used as a livelihood and income diversification strategy. Individuals, households and even communities tend to adopt migration as a strategy to enhance their livelihoods, so that it is considered the norm rather than the exception. However, migration choices may cause people to fall into poverty or prop up existing poverty of both the migrant and sending households. The relationship between poverty and migration is therefore not unidirectional, especially because poverty is multifaceted and migration is not a homogeneous livelihood strategy. Anarfi et al. (2003) note, that in Ghana migration is the basic survival strategy for individuals and families coping with difficult economic conditions. In a study of migration and poverty in Ghana and Egypt, Sabates-Wheeler, Sabates, and Castaldo

(2008) show that poverty is a positive and significant determinant of migration, and that migration can have a significant impact in helping poor people move out of poverty. The study observes that migration choice in Ghana is determined, among other things, by age, gender, marital status, and education level.

Awumbila and Ardayfio-Schandorf (2008) report that more recent north to south migration in Ghana is dominated by female youths, moving independently of their families, and settling in the cities of Accra and Kumasi. At these destinations, young girls serve as kayayei —female head porters who carry goods for a negotiated fee. Awumbila and Ardayfio-Schandorf point out that these girls use migration as the means to address their livelihood needs. But away from their home community support and families, most end up living and working under very poor conditions that expose them to both physical and reproductive health risks.

North-south migration in Ghana is generally rooted in the underdevelopment and poverty of the three northern regions dating to colonial times, when the north supplied labor for economic development in the south (Awumbila and Ardayfio-Schandorf 2008; Van der Geest, Vrieling and Dietz 2010). Most migrants from the north worked in mines, cocoa farms and road construction. British colonial policy largely promoted the north as a labor reserve for economic development in the south. The result is that while the north saw little investment in both infrastructure and services, the south saw a massive infusion of capital to develop and extract its mineral resources, cash crops and timber export. After many decades of consistent underdevelopment of the north, it is now estimated that about 80% of the population in the three northern regions is poor with 70% falling in the extremely poor category (Awumbila and Ardayfio-Schandorf 2008).

Even though migration does not directly determine childhood mortality, the relationship is well explained by differences in socioeconomic status between rural-urban migrants and urban natives. Islam and Azad (2008) report from Bangladesh that although infant and child mortality indices were consistently better in urban areas, urban-rural differentials have diminished in recent times. They observed higher under-five mortality among children born to urban migrants compared to urban natives. The migrant-native mortality differentials tracked differences in socioeconomic status. Rural-urban migrants appeared to be moderately disadvantaged in terms of economic status and healthcare utilization compared to urban natives. Thus, in urban areas, child survival status was worse for the migrant poor than the average urban poor. The slower decline in under-five mortality in urban areas and hence the diminishing urban-rural differentials in childhood mortality could therefore be a product of recent rapid growth in urban populations and the higher risk of mortality among children of migrants. The relatively disadvantaged status of urban migrants notwithstanding, the survival chances of their children were still better than their rural natives. Positive migrant selection and duration of residence in the city may account for this difference but what this suggests is that rural-urban migration promotes child survival.

In India, Choudhary and Parthasarathy (2009) examined the role of migration in both mother and child malnutrition and observed a link. The study shows that not all migrants are necessarily vulnerable. Migrants originating from rural areas are more likely to be nutritionally disadvantaged compared to those from urban areas because urban migrants experience comparable if not better nutritional security as non-migrants/urban natives. But the duration of migration is not unimportant as shorter migration duration makes children of migrants more vulnerable to nutrition insecurity. For shorter duration of migration, Choudhary and Parthasarathy (2009) found that children of non-migrant mothers had lower probability of stunting compared to children of urban migrants. Longer migration duration on the other hand had relatively insignificant impact on child stunting.

In Niger, Hampshire et al. (2009) report increased female-headed households largely due to male labor migration and point out that while children's nutritional status is not associated with out-migration of fathers; children whose fathers are present have lower wasting scores than children of migrant fathers. There is also conflicting impact of migration on women and children. On the one hand, shifts in intra-household power relations and decision making provide some women with more control over immediate household resources in the absence of their husbands but on the other hand, control of household resources could be delegated to other family members, constraining the ability of some women to negotiate adequate share of resources for nutrition and health of their children. In rural Northeast Thailand, Cameron and Lim (2007) point out that once other explanatory variables were taken into account, child height-for-age was unaffected by migration or household composition. Also, if only one parent is present (suggesting the other parent had migrated), the marginal effects on child weight-for-height were less negative. However, if both parents have migrated, the marginal effects were larger. Receipt of remittances from former migrant household members however, provides a positive marginal effect on child weight-for-height and weight-for-age. The suggestion here is that the negative effects of different household types on child nutritional outcome can be mitigated by direct income transfers from migrants.

An important observation from these studies is that high prevalence of illiteracy among women, negligence towards women's health, low skill and gender discrimination in rural areas explain the inferior status of rural-urban migrants. Policy makers should see migrants not as outsiders but as contributing to the economy in terms of providing low cost labor and therefore include them in public food security and health care service planning.

Urbanization

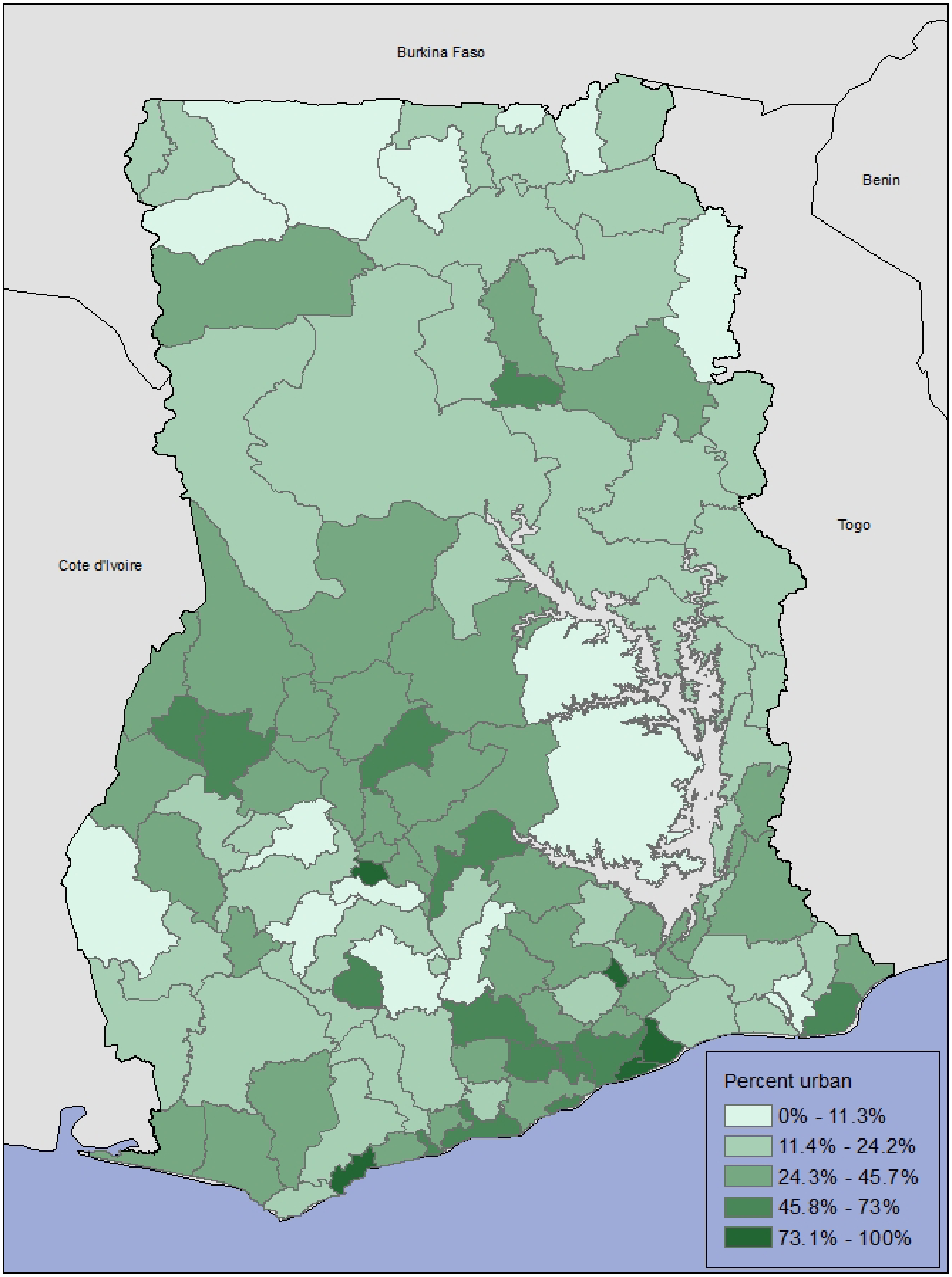
The rapid and unprecedented concentration of humans into cities is a global phenomenon and often represents a response to socioeconomic, political and demographic or environmental conditions. Chirwa and Ngalawa (2008) report a statistically significant impact of urbanization on child underweight and wasting status in Malawi and argue that children in urban areas are significantly more likely to avoid wasting and underweight compared to their rural counterparts. These differential nutritional outcomes reflect both the relatively better income opportunities, access to health facilities and information and education for households and parents in urban areas compared to rural areas.

Khatib and Elmadfa (2009) on the other hand note that rapid urbanization can potentially disrupt socioeconomic and living patterns. Higher prices and living costs limits choices in household purchases and therefore the quality of food available to children. For instance, in north Badia in Jordan, milk and meat had always been available to the Bedouins who were traditionally livestock keepers until urbanization took this lifestyle away and put them on the verge of poverty. This had negative effects on health and nutrition, particularly for children because they were effectively deprived of milk or meat and consequently lost their lactose-tolerance.

Ghana, like many other countries in Sub-Saharan Africa, lacks a clearly articulated urban development strategy, leading to rapid but largely uncontrolled urban growth (Owusu 2008). In the absence of a healthy urban economy, it is almost impossible to provide adequate jobs and services. In the year 2000, 43.8% of Ghana's population was urban with the Accra Metropolitan Area (AMA) alone accounting for 25% of the urban population. Figure 9 below shows that, consistent with the long history of socioeconomic development in Ghana, more districts in the south and middle section of the country are urbanized compared to the northern part.

Also, generally, infectious diseases such as HIV/AIDS are more widespread in urban areas due to higher population densities, migration and lower social control (Jorgensen 2008). In the Kumasi metropolis in Ghana, Osei and Duker (2008) conclude that the spatial clustering of cholera was the result of high urbanization and overcrowding, and in low income neighborhoods in Accra, Arku et al. (2008) found evidence of particle pollution from biomass and traffic sources. No connections have been made between any of the urban studies identified in Ghana and child nutritional outcomes, even though such connections have been observed elsewhere by other studies. This indicates the need to examine this urbanization issue in Ghana for possible links to child health and nutritional outcomes.

Figure 9: Urbanization by district in Ghana



Data source: Ghana Statistical Service 2005

Proximity to health and school facilities

A survey of the literature shows that while most studies examine the health-seeking behavior and barriers to community health access (see Kruk et al. 2010; Moisi et al. 2010; Sasaki et al. 2010), rarely, if at all, do researchers connect community health accessibility issues to children's nutritional well-being. Attempts at making this connection have mostly focused on how, for example, community education and literacy equip mothers and household members with relevant knowledge to make informed decisions about issues like prenatal care, child vaccination and breastfeeding to insure the well-being of children (see Moestue and Huttly 2008; Shin 2007). The present study contributes to scholarship by examining possible links between proximity to hospital, clinic and school facilities within districts in Ghana on the one hand children's nutritional outcome on the other.

It is expected that districts with health and school facilities located farther away from the population would exhibit poorer nutritional outcome among children while those with populations closely located to facilities would show overall positive nutritional outcome among children. The assumption here is that, all things being equal, districts with closely located facilities would be able to reach medical help quicker and therefore be in a position to treat illnesses that impede children's nutritional intake quicker than those with facilities located farther away. Also, with recent implementation of the school feeding program in Ghana, children in districts with closer school facilities would, all things being equal, reap greater benefit from their closer proximity to these facilities than those farther away.

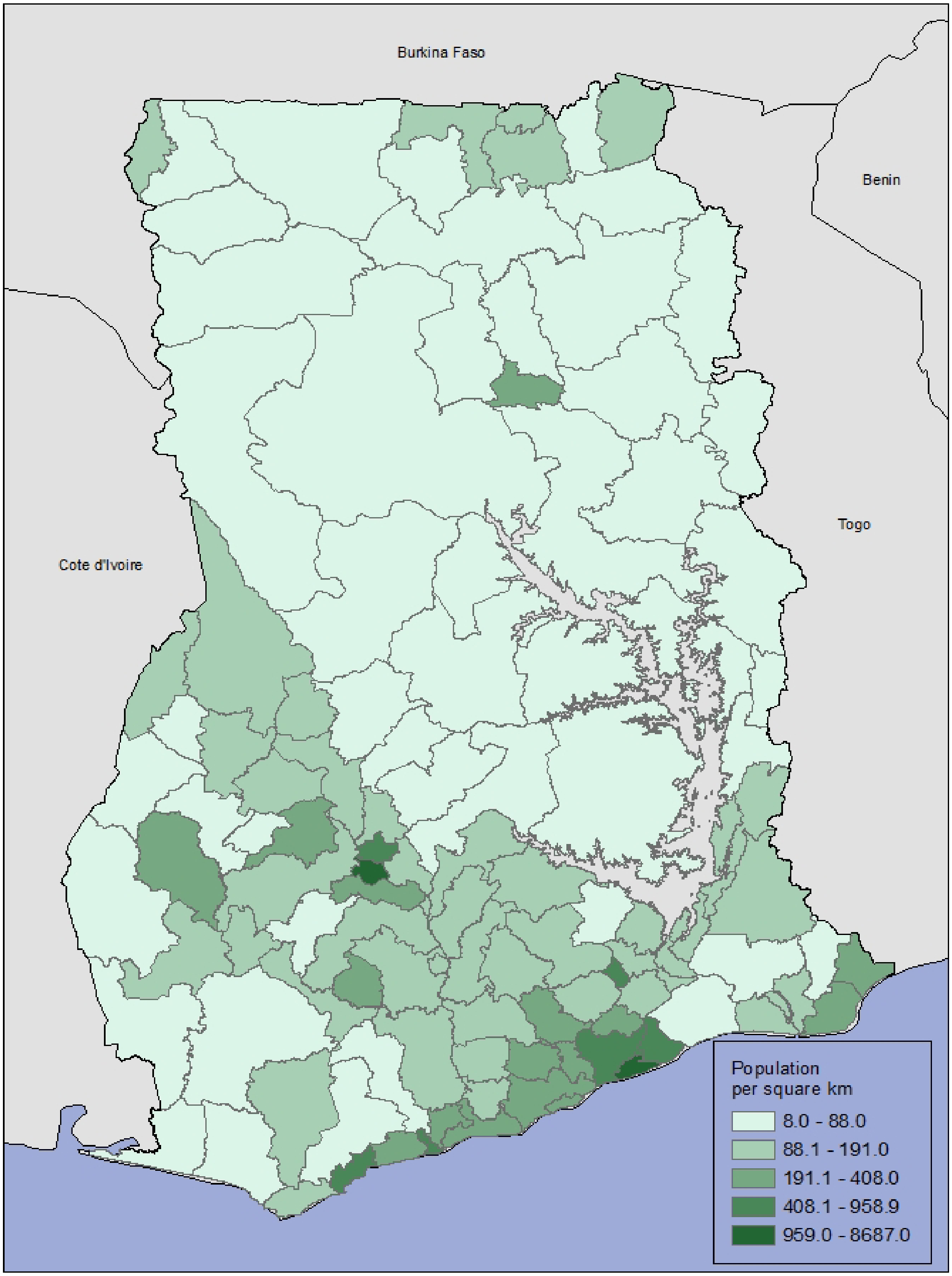
Population density

High population density, particularly in highly urbanized and metropolitan areas, have serious implications for overcrowding and increased pressure on services, and make the maintenance of environmental quality very challenging. These living conditions expose children to the danger of infections that compromise their nutritional well-being (Folake, Cole and Oldewage-Theron 2008). Likewise low population density, usually resulting from out-migration, can result in ghost towns and considerably diminished economic activity, which can have negative consequences for child health and nutrition.

Although studies that examined population density and children's nutritional outcome indicate a relationship, the significance of the relationship is not clear and should be cautiously interpreted. For instance, while Folake, Cole and Oldewage-Theron (2008) found under-nutrition to be most prevalent in highly dense urban communities in Nigeria, Legg (2008) found no significant effect of population densities on malnutrition rates in West Africa, even though actual numbers of malnourished children were highest in areas of very high population density. This discrepancy could be the product of the different scales of the studies because in Bolivia, Anthamatten (2007) also found population density to be negatively associated with stunting, after accounting for the characteristics of children, mothers and households. Since population density may capture a large degree of urbanness, and therefore reduce the likelihood of an independent effect (Balk et al. 2005), caution must be exercised in any study on this subject.

In Ghana, the estimated average population density is about 52 persons per square kilometers with the highest densities in the south (figure 10). For instance, the Accra and Kumasi metropolis with 5530 and 5319 persons per square kilometers, respectively, have the first and second highest population densities in the country (Ghana Statistical Service 2005). Even the Kwabre District, the second most densely populated district in the Ashanti region, has a higher population density than the Tamale municipality in the northern part of the country. The high population density in the south may be explained by the fact that these two regions have the country's largest economies and tend to attract migrants from all over the country.

Figure 10: Population density by district in Ghana



Data source: Ghana Statistical Service 2005

District Exposure Variables and Method

The variables used for district analysis of child nutritional outcomes include ecological zones (treated in chapter 6), population density, poverty index (p0), and district-level wealth quintile, literacy, water and sanitation access, proximity to health and school facilities, residence status and urbanization. Data for these variables were derived primarily from the 2000 Ghana Population and Housing Census (PHC) and Demographic and health survey data (DHS), but data on biomes and ecological zones were acquired from the World Wildlife Fund (WWF).

The national census data identified for each district the density of the population, percent rural (vs. urban), native (vs. migrant), literate (vs. illiterate) and level of urbanization. Since the national census data categorized access to water supply and sanitation a little differently from the 2008 GDHS data and has no wealth quintile categories for districts, the 2008 GDHS data was used for these variables. District percentages for each of these variables were obtained by cross-tabulating the variables and districts in SPSS. Access to water supply was grouped into four categories: pipe water (inside, outside, tanker supply), well (well, borehole), surface/natural (spring, river, stream, lakes, rain water, dugout) and other. Toilet facilities in districts were also categorized as flush toilet, No toilet, Pit facility (pit latrine, KVIP, bucket/pan, facility in another house), public toilet, and other. The headcount index (P_0) measures the proportion of the population that is poor. Although this measure is by far the most widely-used, because of its ease of interpretation, it is a little tricky because it does not indicate how poor the poor are. Data for this variable was acquired from Coulombe (2005).

Administrative districts are used to indicate context because they are the basic spatial units for making most socioeconomic, political and developmental decisions in Ghana and are the basic spatial units for the national census data and the 2008 GDHS population clusters. Regional and district codes embedded in the 2008 GDHS were used to determine the district of residence for each child in the sample. Once districts were established, each child was assigned corresponding characteristics of the selected variables of the district in which they reside. Chapter three above details the statistical procedure utilized to produce the results discussed below.

Analysis of Child Nutritional Outcomes and District Variables

Sample characteristics of district variables

The descriptive statistics for the district socioeconomic variables analyzed in this study are presented in table 8 below. In terms of proximity of hospitals, the results show that almost equal numbers of residents in districts are within 10km or more than 20km away from a hospital. Clinics are however within 10km of majority of district residents and very few people are more than 20km away from the nearest clinic. Surprisingly, although most residents in a district are located within 5km of a school, slightly more district residents are illiterate than literate. A possible explanation could be that on average more districts are rural and while school facilities may exist, they may be lacking in quality. Indeed, while living in the northern part of Ghana, I came across a number of schools that were held under trees and barely convened during important market days.

The data also shows that while few residents in a district have access to pipe water, the greater majority have access to only well water or surface/natural water which are poor in quality. Also most district residents do not have flush toilet and a large percentage of them have no toilets at all. The lack of these basic facilities is reflected in the fact that the vast majority of district residents fall within the poorest and poorer wealth quintiles. In light of these characteristics, it can be surmised that while children could theoretically benefit from being near to hospitals, clinics and schools, the rural nature of most districts coupled with the large number of the poor and lack of basic amenities means that children are more likely to be exposed to conditions with potentially adverse impact their nutritional well-being. In the sections that follow, possible connections between these characteristics and children's nutritional outcome are explored after controlling for all other variables at the child level.

Table 8: Descriptive statistics of district variables

Variable	**n**	**mean**	**z**
Population density	2380	779.6	2052.9
Poverty index (P_0)	2380	0.473	0.2
Proximity to hospital			
10km	2380	37.3	26.6
11-20km	2380	23.6	13.6
> 20km	2380	36.9	26.0
Proximity to clinic			
10km	2380	65.2	22.8
11-20km	2380	18.2	10.9
> 20km	2380	14.4	14.7
Proximity to school			
5km	2380	76.6	18.8
6-10km	2380	14.9	13.0
> 10km	2380	6.8	7.8
Literacy			
illiterate	2380	51.2	22.1
literate	2380	48.1	21.9
Urbanization			
urban	2380	36.3	29.5
rural	2380	63.8	29.6
Residence status			
native	2380	71.7	14.7
migrant	2380	28.2	14.5
Access to water			
pipe water	2380	28.2	24.9
well water	2380	39.4	21.0
surface/natural water	2380	31.3	18.2
other water	2380	1.1	4.3
Access to toilet			
flush toilet	2380	3.682	5.2
without toilet	2380	30.903	31.3
pit toilet	2380	36.454	20.4
public toilet	2380	28.833	15.6
other toilet	2380	0.207	0.3

Wealth quintile			
poorest	2380	32.383	29.6
poorer	2380	22.018	18.2
middle	2380	16.724	14.5
richer	2380	16.931	14.6
richest	2380	11.944	18.0

Data Source: GSS, GHS and ICF Macro 2008; Ghana Statistical Service 2005

Bivariate Analysis of Stunting and District Variables

Table 9 below shows the district variables that are significantly associated with child stunting in Ghana in bivariate analysis. The results show that both the density of the population and the head count index of poverty (P_0) are significantly associated with stunting among children in Ghana. In particular, increasing the head count index of poverty by one unit results in about 3.3 times (95% CI: 2.104-5.031; p<0.0001) more likelihood of stunting among children. In terms of the impact of hospital proximity, the results show that the odds of child stunting is significantly decreased by a factor of 0.99 (95% CI: 0.991-0.998; p=0.003) for every percentage increase in a district's population within 10km of a hospital. On the other hand, a percentage increase in a district's population living more than 20km from a hospital significantly increases the odds of child stunting by a factor of 1.0 (95% CI: 1.002-1.009; p=0.004). Also, although the odds of stunting are reduced if a district's population is 10km from a clinic, and living more than 20km from a clinic facility increases the odds of stunting, these relationships are not significant. Increasing distance to the nearest school is however significantly associated with increasing odds of stunting among children in Ghana. Thus, a one percentage increase in a district's population within 5km of a school reduces the likelihood of child stunting by a factor of 0.99 (95% CI: 2.104-5.031; p<0.0001) but the odds of stunting among children progressively increase for a district's population as distance increases from 11 to 20km to more than 20km from a school facility.

Table 9: Bivariate analysis of stunting and district variables

Variable	β	SE β	Wald's χ2	df	p	eβ (odds ratio)	95% CI for eβ	
							Lower	Upper
Population density	-.116	.031	14.220	1	.000	.891	.839	.946
Poverty index (P_0)	1.180	.222	28.138	1	0.000	3.253	2.104	5.031
Proximity to hospital								
10km	-.006	.002	9.044	1	0.003	.994	.991	.998
11-20km	.007	.004	3.622	1	.057*	1.007	1.000	1.014
> 20km	.005	.002	8.263	1	0.004	1.005	1.002	1.009
Proximity to clinic								
10km	-.002	.002	1.332	1	0.248*	.998	.993	1.002
11-20km	.011	.004	6.210	1	0.013	1.011	1.002	1.020
> 20km	.005	.003	2.385	1	0.123*	1.005	.999	1.011
Proximity to school								
5km	-.007	.003	7.374	1	0.007	.993	.988	.998
6-10km	.013	.004	14.156	1	0.000	1.013	1.006	1.020
> 10km	.014	.006	5.340	1	0.021	1.014	1.002	1.026
Literacy								
illiterate	.012	.002	27.834	1	0.000	1.012	1.007	1.016
literate	-.012	.002	27.534	1	0.000	.988	.984	.993
Urbanization								
urban	-.011	.002	36.721	1	0.000	.989	.985	.992
rural	.011	.002	36.559	1	0.000	1.011	1.008	1.015
Residence status								
native	.011	.003	9.318	1	0.002	1.011	1.004	1.017
migrant	-.012	.004	11.026	1	0.001	.988	.982	.995
Access to water								
pipe water	-.003	.002	1.987	1	0.159*	.997	.993	1.001
well water	.001	.002	.264	1	0.607*	1.001	.997	1.006
surface/natural water	.003	.003	1.583	1	0.208*	1.003	.998	1.009
other water	.004	.011	.109	1	0.741*	1.004	.982	1.025
Access to toilet								
flush toilet	-.020	.010	3.870	1	0.049	.980	.960	1.000
toilet	.002	.002	2.425	1	0.119*	1.002	.999	1.005
pit toilet	-.005	.002	3.699	1	0.054	.995	.991	1.000
public toilet	.000	.003	.001	1	0.976*	1.000	.994	1.006
other toilet	.041	.182	.050	1	0.823*	1.042	.729	1.488

Wealth quintile								
poorest	.006	.002	13.328	1	0.000	1.006	1.003	1.009
poorer	.010	.003	16.625	1	0.000	1.011	1.005	1.016
middle	.000	.003	.043	1	0.835*	0.999	0.993	1.006
richer	-.020	.004	29.942	1	0.000	0.980	0.973	0.987
richest	-.018	.003	29.846	1	0.000	0.982	0.976	0.989

Data Source: GSS, GHS and ICF Macro 2008; Ghana Statistical Service 2005

* Not significant at $p<0.05$ level

In terms of literacy, urbanization and residential status, children are about 0.99 times less likely to be stunted if the percentage of a district's literate, urban and migrant residents is increased by one percent. By contrast, likelihood of stunting among children increases by a factor of 1.0 for every percentage increase in a district's illiterate, rural and native residents. Also, increasing the percentage of residents in a district with piped water access non-significantly reduces the odds of stunting but all the other categories of access to water non-significantly lead to increased odds of stunting among children. A percentage increase in residents in a district with access to flush and pit toilet facilities is however significantly associated with decreased odds of stunting among children in Ghana by a factor of 0.98 (95% CI: 0.960-1.000; $p<0.049$) and 0.99 (95% CI: 0.991-1.000; $p<0.054$) respectively. With the exception of those in the middle wealth quintile, the odds of stunting among children decreased significantly with a percentage increase in a district's population in either the richer or richest wealth quintile and significantly increased with a percentage increase in the population in either the poorest or poorer wealth quintile.

Multivariate Analysis of Stunting and District Variables

To assess the effects of all district characteristics, those that were significantly associated with stunting in the bivariate analysis were simultaneously entered into a logistic regression. Out of twenty variables entered, only two variables namely population density and urban returned as significantly associated with stunting (table 10). The results show that controlling for all other district variables, a percentage increase in a district's urban population significantly reduces the likelihood of stunting among children by a factor of 0.99 (95% CI: 0.982 —0.995; p<0.001). A unit increase in population density also reduces the odds of stunting by a factor of 0.48 (95% CI: 0.269 —0.847; p<0.011). These findings are interesting because the implication is that regardless of the problems associated with urbanization and densely settled areas children are more likely to benefit nutritionally in these contexts than rural or sparsely populated areas.

It is important to point out that the model resulting from this analysis is significant (χ^2 (2) =132.831, p<0.001) and overall, accurately predicts stunting about 78% of the time. The Nagelkerke R Square however shows that the model only explains about 9% of the variation in stunting among children in Ghana.

Table 10: Logistic regression model for stunting and district variables in Ghana

District variable	**β**	**SE β**	**Wald's χ2**	**df**	***p***	**eβ (odds ratio)**	**95% CI for eβ**	
							Lower	**Upper**
Constant	-.753	.087	75.222	1	.000	.471		
Population density	-.739	.292	6.392	1	.011	.478	.269	.847
urban	-.011	.003	11.375	1	.001	.989	.982	.995
	Test					**χ2**	**df**	**p**
Model fit statistics								
Omnibus						132.831	2	0.000
Hosmer & Lemeshow						33.789	8	0.000

Note. Cox and Snell R^2 = .055. Nagelkerke R^2 (Max rescaled R^2) = .085. -2 Log likelihood = 2331.005. Overall percentage predicted = 78.1%. All statistics reported here use 3 decimal places in order to maintain statistical precision.

Data source: GSS, GHS and ICF Macro 2008; Ghana Statistical Service 2005

Full Model for Child Stunting in Ghana

This model brought together all the significantly associated variables for child stunting from both the child and district levels to ascertain which variables remain significant after controlling for the effects of all other variables. Table 11 shows that child age, months of breastfeeding, health insurance, wealth quintile, population density and the percentage of rural residents in a district remain in the model. Not all categories of these variables are significantly associated with stunting however. Particularly, the poorest, middle and richer wealth quintiles were not significantly associated with stunting.

For the variables that are significantly associated, only children of mothers with health insurance had their odds of stunting significantly decreased by a factor of 0.6 (95% CI: 0.482-0.780; p<0.001). The magnitude of the odds ratio is however slightly reduced compared to what it was in the child level only model (table 5).

Table 11: Full logistic regression model for stunting with child and district level variables

Variable	**β**	**SE β**	**Wald's χ2**	**df**	**p**	**eβ (odds ratio)**	**95% CI for eβ**	
							Lower	**Upper**
Constant	-4.087	.511	63.980	1	.000	.017		
Child's age (months)								
0-12*			51.884	3	.000			
13-24	1.641	.244	45.099	1	.000	5.158	3.196	8.326
25-36	1.379	.252	29.948	1	.000	3.973	2.424	6.511
>36	1.621	.234	48.082	1	.000	5.057	3.198	7.995
Months of breastfeeding								
Breastfed < 6 months*			11.558	2	.003			
6 —24 months	.833	.329	6.417	1	.011	2.300	1.207	4.382
> 24 months	1.198	.362	10.920	1	.001	3.313	1.628	6.741
Health insurance (Yes)	-.490	.123	15.871	1	.000	.613	.482	.780
Wealth index								
Richest*			8.487	4	.075			
Poorest	.538	.334	2.591	1	.107	1.712	.890	3.296
Poorer	.691	.332	4.339	1	.037	1.997	1.042	3.827
Middle	.328	.337	.946	1	.331	1.388	.717	2.685
Richer	.240	.340	.499	1	.480	1.271	.653	2.475
District variables								
Population density	-.674	.289	5.435	1	.020	.510	.289	.898
rural	.008	.004	3.912	1	.048	1.008	1.000	1.015
Test						**χ2**	**df**	**p**
Model fit test								
Omnibus						281.892	12	0.000
Hosmer & Lemeshow						8.096	8	0.424

Note. Cox and Snell R^2 = .125. Nagelkerke R^2 (Max rescaled R^2) = .192. -2 Log likelihood = 1932.544. Overall percentage predicted = 78.2%. All statistics reported here use 3 decimal places in order to maintain statistical precision.

Data source: GSS, GHS and ICF Macro 2008; Ghana Statistical Service 2005
*Reference group

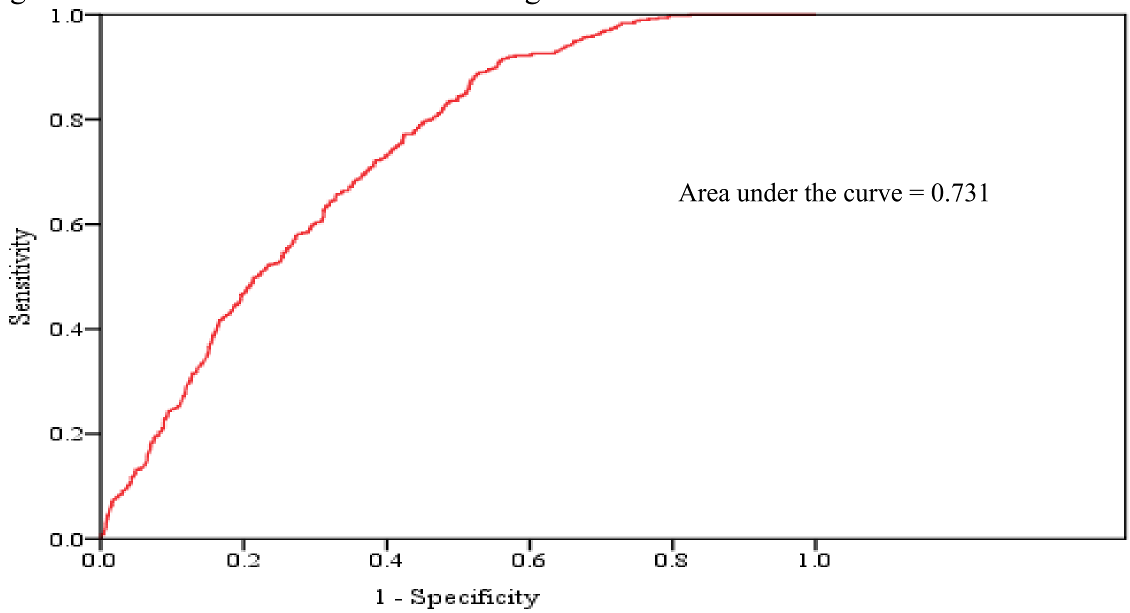
Stunting continued to vary by age group with children aged 13-24 months showing the greatest odds of stunting (OR=5.2; 95% CI: 3.196-8.326; p<0.001), but only slightly so more than children older than 36 months when compared to the referenced age group. Compared to the child level only model, the odds ratios increased by about 0.31, 0.32 and 0.33 respectively for children age 13 —24 months, 25 —36 months and more than 36 months.

Prolonged breastfeeding also continued to increase the odds of stunting among children but the odds ratios remained fairly the same compared to the child level only model. Population density continued to reduce the odds of stunting. The percentage of rural residents in a district did not show significance in the district level only model, but it was retained in this model with borderline significance. The results show that one percent increase in the rural population raised the odds of child stunting by a factor of about 1.0 (95% CI: 1.000-1.015; p<0.048).

Full Model Evaluation for Child Stunting

A number of statistics from the full model tell us how well this model does as compared to the child level only model. First, the -2 Log likelihood statistic shows decrease from 2087.634 in the child level only model to 1932.544 in the full model, indicating that the full model does better at predicting stunting among the cases examined. Although the overall percentage of stunting correctly predicted by this model does not increase appreciably over the child level only model (78.2% compared to 77%), the amount of variation in stunting explained, as indicated by the Nagelkerke R Square, increased from 14.5% in the child only model to 19.2% in the full model. The model also fits the data well as pointed out by the non-significance of the Hosmer-Lemeshow goodness of fit (χ^2 (8) =8.096.831, p=0.424). Furthermore, the receiver operating characteristic (ROC) area of 0.731 in figure 11 below means that in about 73% of all possible pairs of children, if one is stunted and the other is not, the model will assign a higher probability to the stunted child.

Figure 11: ROC curve and area for stunting



Bivariate Analysis of Underweight and District Variables

Several district socioeconomic variables are significantly associated with underweight among children in bivariate analysis (table 12). These include population density, head count poverty (P_0), proximity to a school, literacy, urbanization, residence status, access to toilet facility and wealth quintile, even though not all categories of these variables are significantly associated. Surprisingly, proximity of residents of a district to a hospital or clinic, and access to any type of water source are not significantly associated with underweight among children in Ghana.

Among the significantly associated district variables, the results show that a percentage increase in a district's population within 5km of a school significantly reduces the odds of underweight among children by a factor of 0.99 (95% CI: 0.988-0.998; p=0.012). But if the residents in a district are more 6km from a school, then increasing the population by one percent significantly increases the odds of underweight among children by a factor of about 1.0. Children are most at risk of underweight if they are more than 10km from the nearest school. Also, the odds of underweight among children are reduced if they live in a district with literate (vs. illiterate) residents.

Table 12: Bivariate analysis of underweight and district variables

Variable	β	SE β	Wald's χ2	df	p	eβ (odds ratio)	95% CI for eβ Lower	Upper
Population density	-.063	.030	4.443	1	.035*	.939	.885	.996
Poverty index (P_0)	1.335	.244	30.034	1	.000*	3.801	2.358	6.128
Proximity to hospital								
10km	-.001	.002	.291	1	.590	.999	.995	1.003
11-20km	.000	.004	.014	1	.904	1.000	.993	1.008
> 20km	.004	.002	3.134	1	.077	1.004	1.000	1.008
Proximity to clinic								
10km	.001	.002	.132	1	.716	1.001	.996	1.005
11-20km	.003	.005	.361	1	.548	1.003	.993	1.013
> 20km	.005	.004	2.425	1	.119	1.005	.999	1.012
Proximity to school								
5km	-.007	.003	6.347	1	.012*	.993	.988	.998
6-10km	.015	.004	17.210	1	.000*	1.016	1.008	1.023
> 10km	.021	.006	10.959	1	.001*	1.021	1.009	1.034
Literacy								
illiterate	.016	.002	41.492	1	.000*	1.016	1.011	1.021
literate	-.016	.002	41.438	1	.000*	.984	.980	.989
Urbanization								
urban	-.010	.002	22.831	1	.000*	.990	.986	.994
rural	.010	.002	22.732	1	.000*	1.010	1.006	1.014
Residence status								
native	.016	.004	16.485	1	.000*	1.016	1.008	1.024
migrant	-.015	.004	15.596	1	.000*	.985	.977	.992
Access to water								
pipe water	-.003	.002	2.215	1	.137	.997	.992	1.001
well water	.001	.003	.228	1	.633	1.001	.996	1.006
surface/natural water	.004	.003	2.046	1	.153	1.004	.998	1.010
other water	.003	.012	.053	1	.817	1.003	.980	1.026
Access to toilet								
flush toilet	-.027	.012	5.205	1	.023*	.974	.951	.996
toilet	.006	.002	13.761	1	.000*	1.006	1.003	1.009
pit toilet	-.012	.003	20.210	1	.000*	.988	.983	.993
public toilet	-.003	.003	.669	1	.413	.997	.991	1.004
other toilet	.113	.193	.345	1	.557	1.120	.768	1.634

Wealth quintile								
poorest	.009	.002	28.684	1	.000*	1.009	1.006	1.013
poorer	.001	.003	.123	1	.726	1.001	.995	1.007
middle	-.005	.004	2.053	1	.152	.995	.987	1.002
richer	-.018	.004	21.295	1	.000*	.982	.974	.990
richest	-.015	.003	18.318	1	.000*	.985	.978	.992

Data source: GSS, GHS and ICF Macro 2008; Ghana Statistical Service 2005

*significant at $p<0.05$ level

Increasing the percentage of literate residents in a district by one percent significantly cuts the odds of underweight among children by a factor of 0.98 (95% CI: 0.980-0.989; $p<0.001$). On the contrary, a percentage increase in the illiterate residents in a district significantly increase the odds of child underweight by a factor of 1.0 (95% CI: 1.011-1.021; $p<0.001$). Similarly, increasing the percentage of urban and migrant residents in a district, as well as the percentage of residents in a district with access to flush and pit toilet facilities significantly reduce the odds of underweight among children in Ghana. Additionally, increasing the proportion of a district's population in the richer and richest wealth quintiles cut the odds of child underweight by a factor of 0.98.

Other factors like the proportion of a district's population in the poorest wealth quintile, having no toilet facilities, and rural and native residents of a district significantly increase the odds of child underweight in Ghana by a factor of 1.0 for every percentage increase in these variables.

Multivariate Analysis of Underweight and District Variables

A multivariate logistic regression was used to assess together the effects of all the significantly associated district variables from the bivariate analysis of underweight above. Although seventeen variables were entered into the logistic regression, only three variables namely population density, percentage of illiterate residents in a district and proportion of a district's population in the poorest wealth quintile were retained (table 13). Increasing the population density by one unit leads to a significant decline in the odds of underweight among children by a factor of 0.99 (95% CI: 0.997-0.999; $p=0.001$). But increasing the percentage of illiterate residents in a district by one percent increases the odds of child underweight significantly by a factor of 1.0 (95% CI: 1.018-1.043; $p<0.001$).

A rather surprising result from the analysis is that increasing the proportion of a district's population in the poorest wealth quintile leads to a significant decrease in the odds of underweight among children in Ghana. This finding clearly defies logical reasoning. It is suspected that a number of confounding factors that are not immediately decipherable might be at play. Further analysis in the future is warranted to extricate the factors that are either moderating or mediating the effects of the poorest wealth quintile on underweight among children. Nonetheless, the model is significant (χ^2 (3) =153.457, $p<0.001$) and explains about 11% of the variance in child underweight as indicated by the Nagelkerke R Square statistic. Overall, the model also correctly predicts about 84% of child underweight even though the significance of the Hosmer and Lemeshow goodness of fit test (χ^2 (8) =17.861, $p<0.022$) suggests the model is not properly fitted to the data.

Table 13: Logistic regression model for underweight with district variables

Variable	**β**	**SE β**	**Wald's χ2**	**df**	**p**	**eβ (odds ratio)**	**95% CI for eβ**	
							Lower	**Upper**
Constant	-2.621	.284	85.335	1	.000	.073		
Population density	-.002	.001	11.036	1	.001	.998	.997	.999
illiterate	.030	.006	24.199	1	.000	1.030	1.018	1.043
poorest	-.011	.004	7.185	1	.007	.990	.982	.997
Test						**χ2**	**df**	**p**
Model fit test								
Omnibus						153.457	3	0.000
Hosmer & Lemeshow						17.861	8	0.022

Note. Cox and Snell R^2 = .064. Nagelkerke R^2 (Max rescaled R^2) = .108. -2 Log likelihood = 1925.647. Overall percentage predicted = 83.6%. All statistics reported here use 3 decimal places in order to maintain statistical precision.

Data Source: GSS, GHS and ICF Macro 2008; Ghana Statistical Service 2005

Full Model for Child Underweight in Ghana

Table 14 presents a full model for child underweight in Ghana. Like the full stunting model, the aim here is to put all the variables that are significantly associated with underweight at both child and district levels into one multivariate logistic regression and assess the effects of all the variables together. The significant variables after controlling for the effects of all other variables include child age 13-24 months, all categories of months of breastfeeding, the poorer and poorest categories of wealth quintile, the "other" category of family ethnicity, percentage of illiterate residents in a district and proportion of poorest residents in a district. Of these variables, only the other category of family ethnicity and proportion of poorest residents in a district reduce the odds of underweight among children.

All other significantly associated variables increase the odds of child underweight with a unit increase in the variable. In particular, the odds of underweight among children age 13-24 months are significantly increased by more than twice the odds of underweight in the referenced age group. This association and the magnitude of the odds ratio did not change from the child level model. The odds of underweight also increased by a factor ranging from 3.3 to 6.3 with increasing months of breastfeeding from six months to more than 24 months. Likewise, the odds of underweight among children in the poorer and poorest household wealth quintiles increased by 3.1 and 3.6 times respectively, compared to the odds of underweight among children in the richest household wealth quintile. Furthermore, as the percentage of illiterate residents in a district increases by one percent, the odds of child underweight increases by a factor of about 1.0 (95% CI: 1.018-1.048; $p<0.001$).

Compared to the magnitudes of the odds ratios in the child level model, all the variables retained in the full model remained largely unchanged. On the other hand, the full model retained the two poor wealth indexes and the 'other' family ethnicity categories that were previously not captured by the child only level model. The proportion of poorest residents in a district continues to reduce the odds of underweight among children in the full model for reasons unclear to this study.

Table 14: Logistic regression model for underweight with child and district variables

Variable	β	SE β	Wald's χ2	df	p	eβ (odds ratio)	95% CI for eβ	
							Lower	Upper
Constant	-5.162	.695	55.223	1	.000	.006		
Child's age (months)								
0-12			35.265	3	.000			
13-24	.716	.209	11.753	1	.001	2.046	1.359	3.081
25-36	.235	.227	1.076	1	.300	1.265	.811	1.974
>36	-.248	.212	1.379	1	.240	.780	.515	1.181
Months of breastfeeding								
Breastfed < 6 months			24.265	2	.000			
6 —24 months	1.194	.333	12.836	1	.000	3.300	1.717	6.340
> 24 months	1.843	.382	23.243	1	.000	6.316	2.986	13.361
Mother's occupation								
Not working			8.049	3	.045			
Agriculture sector	.303	.259	1.374	1	.241	1.354	.816	2.249
Manual worker	-.087	.329	.070	1	.791	.916	.481	1.746
Other	-.152	.273	.312	1	.577	.859	.503	1.466
Wealth index								
Richest			8.327	4	.080			
Poorest	1.290	.505	6.533	1	.011	3.633	1.351	9.772
Poorer	1.136	.496	5.240	1	.022	3.114	1.177	8.237
Middle	.853	.501	2.898	1	.089	2.348	.879	6.270
Richer	.948	.504	3.542	1	.060	2.581	.962	6.928
Family ethnicity								
Akan			13.704	4	.008			
Ga/Dangme	.136	.368	.137	1	.711	1.146	.557	2.359
Ewe	-.313	.239	1.709	1	.191	.731	.458	1.169
Mole-Dagbani	-.339	.212	2.570	1	.109	.712	.471	1.078
Other	-.790	.232	11.618	1	.001	.454	.288	.715
District variables								
Population density	.000	.000	2.812	1	.094	.999	.998	1.000
illiterate	.033	.007	19.232	1	.000	1.033	1.018	1.048
poorest	-.011	.005	5.845	1	.016	.989	.980	.998
Test						**χ2**	**df**	**p**
Model fit test								
Omnibus						240.448	19	0.000
Hosmer & Lemeshow						6.567	8	0.584

Note. Cox and Snell R^2 = .109. Nagelkerke R^2 (Max rescaled R^2) = .185. -2 Log likelihood = 1609.266. Overall percentage predicted = 84%. All statistics reported here use 3 decimal places in order to maintain statistical precision.

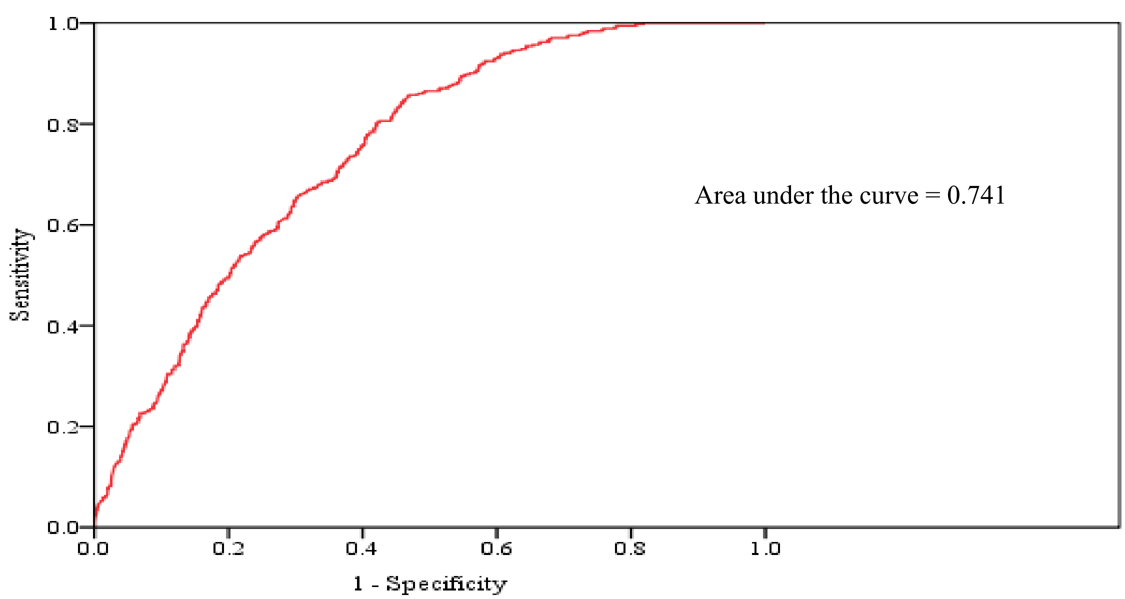
Data source: GSS, GHS and ICF Macro 2008; Ghana Statistical Service 2005

Full Model Evaluation for Child Underweight

Several statistics point to a good model for assessing the variables significantly associated with underweight among children in Ghana. First, the overall model is significant (χ^2 (19) =240.448, p<0.001) and properly fits the data as indicated by the non-significance of the Hosmer and Lemeshow goodness of fit test (χ^2 (8) =6.567, p=0.584). Similarly, as the Nagelkerke R Square shows, while the child level only model explained about 15% of the variation in underweight among children, the full model explains about 19% of the variation in underweight and therefore shows an improvement of about 27% more explanation power over the child level only model. Furthermore, the overall accuracy of the full model to predict underweight among children in Ghana improves to 84% in this final model.

Another way to assess the quality of this model is to determine whether -2 Log likelihood decreases from the child only level model to the current full model. A smaller statistic shows a better model. A comparison with the child only model shows that -2 Log likelihood decrease from 1879.539 to 1609.266 in the full model. Finally, figure 12 shows the ROC area is 0.741, indicating that the full model assigns a higher probability to an underweight child out of a possible pair of cases.

Figure 12: ROC curve and area for underweight



Bivariate Analysis of Anemia and District Variables

The results in table 15 show the variables that exhibited significant bivariate relationship with anemia among children in Ghana. Living within 10km of the nearest hospital and 5km from the nearest school, a literate population, an urbanized and migrant population, access to flush or pit toilet facility and richer and richest wealth quintiles significantly reduced the odds of anemia among children in Ghana. In particular, the odds of anemia among children are reduced almost by a factor of 1.0 for every unit of increase in these variables.

On the other hand, residents that are more than 20km from the nearest hospital or more than 10km from the nearest clinic and more than 6km from the nearest school, as well as illiterate and native population, having no access to a toilet facility and poorer and poorest wealth quintile significantly increase the odds of anemia among children in Ghana. An increase of one unit in any of these variables leads to a significant increase in the odds of anemia by a factor of more than 1.0. The odds of anemia is increased the most, 5 times (95% CI: 3.098-8.230; $p<0.001$), for every unit of increase in the head count of poverty (P_0).

Remarkably, none of the categories of access to water in a district was significantly associated with anemia, even though the odds of anemia appears to decline with a district's population access to pipe water. Moreover, living within 10km of a clinic reduces the odds of anemia by a factor of 0.99 but non-significantly.

Table 15: Bivariate analysis of anemia and district variables

Variable	β	SE β	Wald's χ2	df	p	eβ (odds ratio)	95% CI for eβ	
							Lower	Upper
Population density	.000	.000	25.141	1	.000	1.000	1.000	1.000
Poverty index (P_0)	1.619	.249	42.198	1	.000	5.049	3.098	8.230
Proximity to hospital								
10km	-.008	.002	17.491	1	.000	.992	.988	.996
11-20km	.001	.004	.019	1	.890*	1.001	.993	1.008
> 20km	.014	.002	37.321	1	.000	1.014	1.009	1.018
Proximity to clinic								
10km	-.004	.002	3.359	1	.067*	.996	.991	1.000
11-20km	.019	.005	14.184	1	.000	1.019	1.009	1.029
> 20km	.014	.004	12.185	1	.000	1.014	1.006	1.022
Proximity to school								
5km	-.007	.003	5.480	1	.019	.993	.987	.999
6-10km	.028	.005	28.493	1	.000	1.028	1.018	1.039
> 10km	.019	.008	6.349	1	.012	1.019	1.004	1.034
Literacy								
illiterate	.020	.003	58.172	1	.000	1.020	1.015	1.025
literate	-.020	.003	58.199	1	.000	.980	.975	.985
Urbanization								
urban	-.013	.002	60.471	1	.000	.987	.983	.990
rural	.013	.002	60.180	1	.000	1.013	1.010	1.017
Residence status								
native	.014	.003	15.414	1	.000	1.014	1.007	1.021
migrant	-.015	.004	17.333	1	.000	.985	.979	.992
Access to water								
pipe water	-.003	.002	2.372	1	.124*	.997	.993	1.001
well water	.002	.003	.453	1	.501*	1.002	.997	1.007
surface/natural water	.003	.003	1.322	1	.250*	1.003	.998	1.009
other water	.009	.013	.538	1	.463*	1.010	.984	1.036
Access to toilet								
flush toilet	-.028	.009	8.543	1	.003	.973	.955	.991
without toilet	.004	.002	5.429	1	.020	1.004	1.001	1.008
pit toilet	-.008	.003	9.258	1	.002	.992	.987	.997
public toilet	.001	.003	.069	1	.793*	1.001	.994	1.008
other toilet	-.074	.201	.134	1	.714*	.929	.626	1.378

Wealth quintile								
poorest	.012	.002	39.472	1	.000	1.012	1.009	1.016
poorer	.010	.003	9.350	1	.002	1.010	1.003	1.016
middle	-.004	.004	1.344	1	.246*	.996	.989	1.003
richer	-.023	.004	41.742	1	.000	.977	.970	.984
richest	-.020	.003	52.752	1	.000	.981	.975	.986

Data source: GSS, GHS and ICF Macro 2008; Ghana Statistical Service 2005

Multivariate Analysis of Anemia and District Variables

In the multivariate logistic regression analysis, all the significantly associated district variables from the bivariate analysis were simultaneous analyzed as shown in table 16. The aim was to refine the bivariate analysis, taking into account the possible influences of all variable in the bivariate relationships. The results show that a percentage increase in illiterate and rural residents in a district and the proportion of a district's population in the poorest wealth quintile increases the odds of anemia among children by a factor of about 1.0. For instance, a one percent increase in a district's illiterate population increases the odds of children's anemia by a factor of 1.04 (95% CI: 1.024-1.055; p<0.001).

Rather unexpectedly, this study found that an increase in the head count of poverty (P_0) by one unit decreases child anemia by a factor of 0.2 (95% CI: 0.040-0.570; p=0.005). This finding does not lend itself to any immediate explanation, especially because the model also indicates that the proportion of a district's population in the poorest wealth quintile actually increases the odds of anemia among children. It can only be speculated here that other variables with child anemia reducing effects might be mediating or moderating the true impact of the head count of poverty variable.

The overall model is however significant (χ^2 (4) =178.224, p<0.001) and explains about 13% of the total variation in anemia as indicated by the Nagelkerke R Square. Overall, the model also correctly predicts about 83% of anemia. The significance of the Hosmer and Lemeshow test of model fitness however suggests that the model does not adequately fitted the data.

Table 16: Logistic regression model for anemia with district variables

Variable	β	SE β	Wald's χ2	df	*p*	eβ (odds ratio)	95% CI for eβ Lower	Upper
Constant	.027	.163	.027	1	.869	1.027		
illiterate	.038	.008	25.139	1	.000	1.039	1.024	1.055
rural	.006	.003	4.240	1	.039	1.006	1.000	1.012
poorest	.010	.004	6.792	1	.009	1.010	1.003	1.018
Poverty index (P_0)	-1.887	.676	7.788	1	.005	.152	.040	.570
Test						**χ2**	**df**	**P**
Model fit test								
Omnibus						178.224	4	0.000
Hosmer & Lemeshow						37.912	8	0.000

Note. Cox and Snell R^2 = .081. Nagelkerke R^2 (Max rescaled R^2) = .134. -2 Log likelihood = 1772.132. Overall percentage predicted = 82.5%. All statistics reported here use 3 decimal places in order to maintain statistical precision.

Data source: GSS, GHS and ICF Macro 2008; Ghana Statistical Service 2005

Full Model for Child Anemia in Ghana

In this model a multivariate logistic regression analysis was implemented to combine all the significantly associated variables from the child and district levels of analysis. The goal is to understand how these variables simultaneously affect anemia among children in Ghana. The results are presented in table 17 below. It shows that, like the child level only model, the odds of anemia are again significantly reduced by a factor of 0.4 (95% CI: 0.252-0.664; p<0.001) among children older than 36 months compared to the referenced age group.

Also for every percentage increase in a district's literate population, the odds of anemia among children declines by a factor of about 1.0 (95% CI: 0.959 —0.986; p<0.001). Like the child level model, the odds of anemia is reduced by a factor of 0.5 (95% CI: 1.024 —1.055; p<0.001) among children with access to 'other' sources of water supply compared to children with access to piped water. Other findings show that more than 10 visits for prenatal care during pregnancy and being age 25 —36 month old non-significantly reduce the odds of anemia among children.

Table 17: Logistic regression model for anemia with child and district level variables

Variable	**β**	**SE β**	**Wald's χ2**	**df**	**p**	**eβ (odds ratio)**	**95% CI for eβ Lower**	**Upper**
Constant	1.888	.486	15.122	1	.000	6.608		
Child's age (months)								
0-12*			32.942	3	.000			
13-24	.287	.263	1.183	1	.277	1.332	.795	2.232
25-36	-.083	.280	.089	1	.766	.920	.532	1.592
>36	-.894	.247	13.111	1	.000	.409	.252	.664
Had fever in last two weeks								
Yes	.790	.232	11.581	1	.001	2.203	1.398	3.471
Mother's health status								
Anemic	.749	.191	15.476	1	.000	2.116	1.457	3.074
Prenatal care								
<3 visits*			12.540	2	.002			
3-9 visits	1.461	.479	9.321	1	.002	4.312	1.688	11.020
>10 visits	-.403	.247	2.662	1	.103	.669	.412	1.084
Wealth index								
Richest*			14.793	4	.005			
Poorest	1.377	.409	11.347	1	.001	3.962	1.778	8.827
Poorer	.829	.345	5.791	1	.016	2.292	1.166	4.503
Middle	.718	.333	4.663	1	.031	2.051	1.069	3.938
Richer	.160	.273	.345	1	.557	1.174	.688	2.002
Water supply								
Piped water*			8.955	3	.030			
Well water	.373	.230	2.633	1	.105	1.453	.925	2.281
Surface water	.198	.337	.347	1	.556	1.219	.630	2.359
Other	-.691	.301	5.269	1	.022	.501	.278	.904
District variable								
literate	-.028	.007	16.441	1	.000	.972	.959	.986
richest	.022	.007	9.604	1	.002	1.022	1.008	1.037
Test						**χ2**	**df**	**p**
Model fit test								
Omnibus						208.952	16	0.000
Hosmer & Lemeshow						4.325	8	0.827

Note. Cox and Snell R^2 = .154. Nagelkerke R^2 (Max rescaled R^2) = .262. -2 Log likelihood = 897.184. Overall percentage predicted = 84.4%. All statistics reported here use 3 decimal places in order to maintain statistical precision.

Data source: GSS, GHS and ICF Macro 2008; Ghana Statistical Service 2005
*Reference group

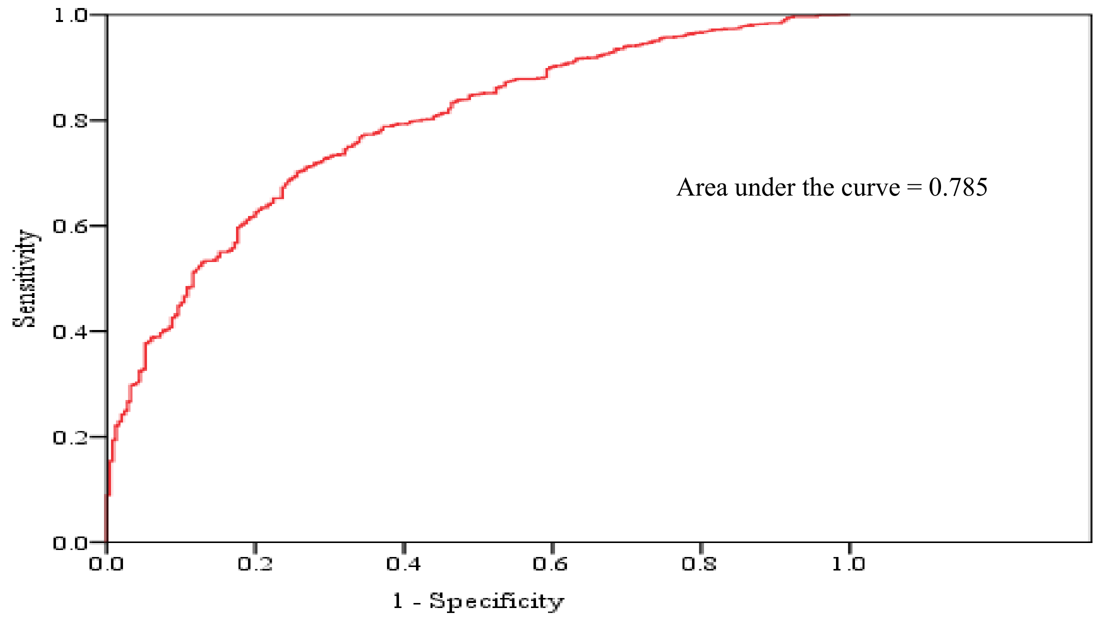
Factors that significantly increase the odds of anemia among children in the full model include mother's anemic condition (OR = 2.1; 95% CI: 1.457 —3.074; $p<0.001$), fever in the two weeks preceding the survey (OR = 2.2; 95% CI: 1.398 —3.471; $p=0.001$), 3 —9 visits for prenatal care (OR = 4.3; 95% CI: 1.688 —11.020; $p=0.002$) and the proportion of a district's population in the richest wealth quintile (OR = 1.0; 95% CI: 1.008 —1.037; $p=0.002$).

It is also worth pointing out that even though the proportion of a district's population in the poorer and poorest wealth quintile were significantly associated with anemia in the child level only model, they failed to show significance in the full model. All the other variables from the child level model however, showed only slight coefficient adjustments in the full model. The variables from the district level model, on the other hand, were completely replaced by new variables. This is a little puzzling but indicates that controlling for the child level variables significantly affect which district variables are relevant for explaining anemic conditions among children in Ghana.

Full Model Evaluation for Child Anemia

An evaluation of key model statistics show that overall the full model is significant (χ^2 (16) = 208.954, $p<0.001$) and comparatively explains about 9% more of the variation in anemia among children (26% versus 17.6% in the child level only model) as specified by the Nagelkerke R Square. The model is also adequately fitted to the data as indicated by the non-significance of the Hosmer and Lemeshow test of model fitness (χ^2 (8) = 4.325, $p=0.827$) and overall, accurately predicts about 84% of anemia. The decrease in -2 Log likelihood statistics from 1063.235 to 897.184 is also a good sign that the full model is indeed better for explaining children's anemic status than the child level only model. Another important way to examine the full model is to use the area under the ROC curve to assess how it discriminates between any pair of children in the data. As figure 13 shows, the ROC area is 0.785, which means that in almost 79% of all possible pairs of children the full model will assign a higher probability to the anemic child.

Figure 13: ROC curve and area for anemia



Chapter 6

BIOPHYSICAL ENVIRONMENT AND CHILD NUTRITIONAL OUTCOMES

Biophysical Environment and Nutrition

Some scholarship, particularly by climatologists, biologists, ecologists and soil scientists, focus on the biophysical environment but few make a connection to nutritional well-being (see Chapman et al. 2003; Gober 2010; Materechera 2010; Stepniewski, Horn, Martyniuk 2002). Work that examines this connection shows that the biophysical environment has important implications for children's nutritional outcome through its impact on the potential for agricultural sustainability and food production. Factors such as rainfall amounts and duration, as well as quality of soil and moisture content are among a host of biophysical environmental conditions that impact the quantity, quality and diversity of food produced.

Dickinson et al. (2009, 254) observes from reviewing the soil-plant-human nutrition pathway for women and children in Malawi that "in many developing countries food insecurity and malnutrition are the result of poor soil fertility, low levels of available mineral nutrients in soil, inadequate nutrient management and lack of plant genotypes with high tolerance to nutrient deficiencies". The ideal strategy most farmers adapt is to leave a portion of the land fallow each season to allow nutrients to replenish, but with populations rapidly increasing in Africa, farm plots are becoming increasingly too small for framers to afford this practice. Without regular fertilizer inputs, soils are incapable of providing the essential nutrients to plants and subsequently humans. Dickinson et al. (2009) suggest a methodological model for combining environmental understanding with health and social factors to help rural communities confront the barriers to improving their uptake of micronutrients like iron and zinc.

Examining Tibetan children at high altitudes, Dang et al. (2004) conclude that the nutritional status of the entire population of children is poor and that this is related to the high altitudes at which they reside. Similarly, Ghosh and Kshatriya (2009) conclude from studying coastal, Himalayan and desert ecology in India that the influence of ecology on nutrition and body composition measures is the reason for the significant group differences observed among preschool children. In West Africa, Legg (2008) likewise observed the most serious child malnutrition in the more arid parts, where drought-resistant crops dominate, and the least malnourished children in the more humid and root crops dominant areas.

There is however need for caution in any examination of the links between the biophysical environment and children's nutritional outcome because although Balk et al. (2005, 606) find that "the percentage of a region with sandy soil is positively associated with underweight status", they also point out that the nature of large scale measurements make them highly susceptible to a great deal of error. In light of this, Balk et al. (2005) found household variables explain more variation in child hunger in the developing world than environmental factors. In Bolivia, Anthamatten (2007) likewise acknowledged that while children were more likely to be poorly nourished in the Montane Grasslands than in other biomes, after accounting for selected child, maternal and household characteristics, no definitive conclusions could be made about a causal relationship between biomes and child nutritional outcomes, at least on the basis of the data observed.

The effort of this study to elucidate possible relationships between biomes and ecological regions, on the one hand, and children's nutritional outcomes in Ghana, on the other, is therefore meant to contribute to scholarship in this rather under-researched but nonetheless hugely important area of children's well-being.

Ghana's Biophysical Environment

Ghana's climate is hot and humid in the south and hot and dry in the north. Although about half of the country is less than 500 ft. above sea level, elevation in some parts of the country can reach as high as 2,900 ft. above sea level. Several rivers and streams that crisscross the country are mostly navigable only by canoe. The country also boasts of the largest manmade lake in the world —Volta Lake —for electricity generation, inland transportation, irrigation and fish farming (FAO 2005; GSS, GHS and ICF Macro 2009; WFP 2009).

As in many parts of West Africa, vegetation tends to band in zones. Some studies have simply classified the country into two major biomes, namely Tropical High Forest and Savanna. The high forest has closed forest while the Savanna has mixture of Savanna and Woodland vegetation. About two-thirds of the country is covered by the Savanna biome (Sarpong 2006). Van der Geest, Vrieling and Dietz (2010) and Manu-Aduening et al. (2005) identify four major ecological zones in Ghana, made up of the Southeast Coastal Savanna, the Forest Zone, the Forest-Savanna Transition Zone and the interior Savanna in the north. Other studies divide Ghana into six agro-ecological zones, namely Sudan Savannah Zone, Guinea Savannah Zone, Transition Zone, Semi-deciduous Forest zone, Rain Forest Zone and the Coastal Savannah Zone (FAO 2005; WFP 2009).

The biome and ecological zone classifications used in this study are, however, derived from the World Wildlife Fund (WWF) classification system (WWF 2010), built from careful research designed to represent natural conditions without human intervention (Olson et al 2001). According to this system, Ghana straddles three major habitat biomes namely, Tropical and Subtropical Moist Broadleaf Forests; Tropical and Subtropical Grasslands, Savannas, and Shrublands; and Mangrove. For simplicity this study refers to these biome classes as Guinea Forests, Savannas and Mangroves respectively. The ecological zones are also specified by the Guinea mangroves, Central African mangroves, West Sudanian savanna, Guinea Forest-Savanna Mosaic and Eastern Guinea Forests as shown in figure 14 below. Obviously, there is more to the biophysical environment than just biomes and ecological zones, but these are used as proxy for the biophysical environment in this study because they capture its essence and have data that could be seamlessly combined with other data in this study.

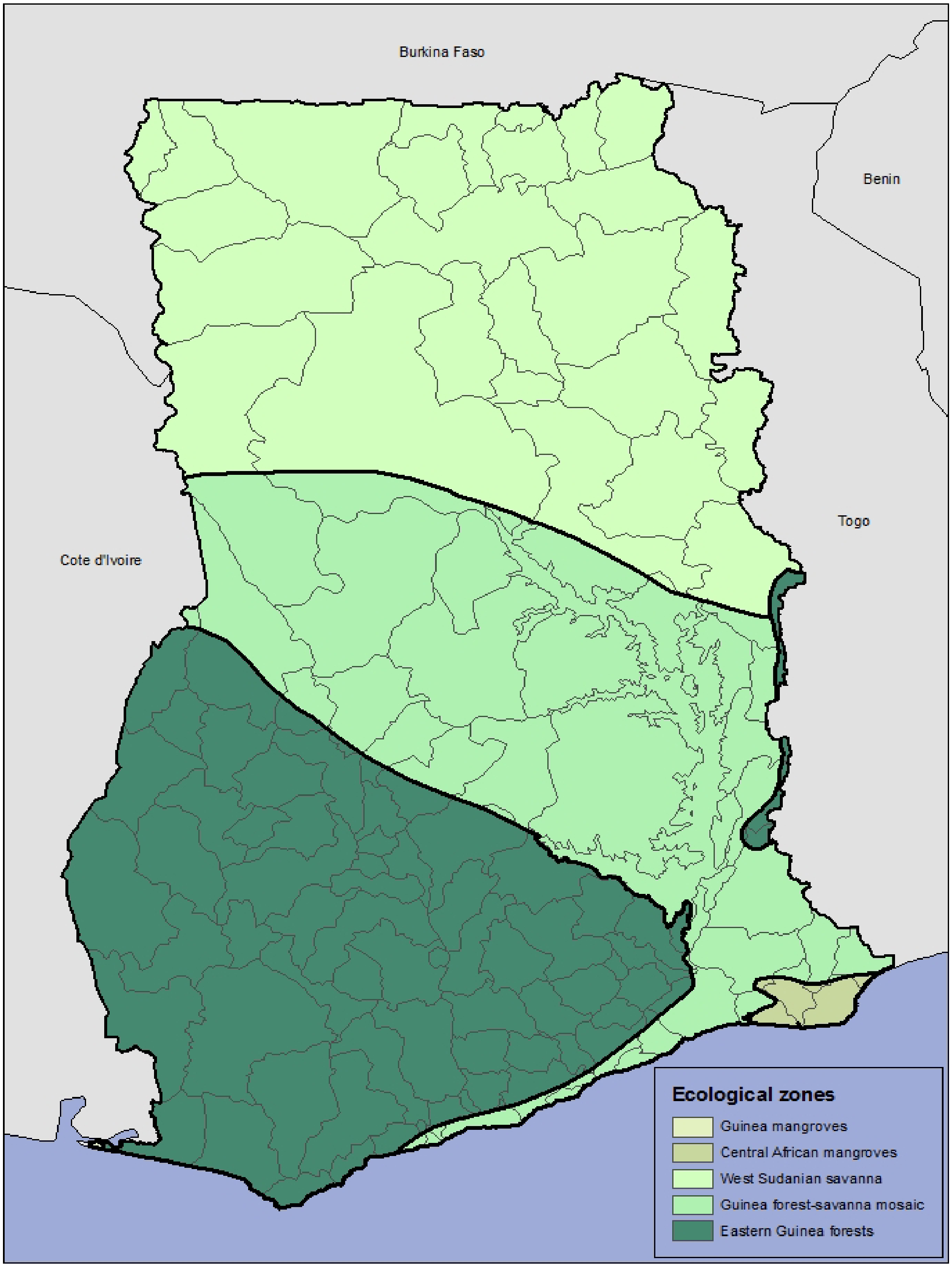
Rainfall pattern plays a major role in establishing these zone classifications. As Manu-Aduening et al. (2005) note, the Central African Mangroves receives relatively little rain (600–800 mm) while the Eastern Guinea Forest is supported by a heavy bimodal rainfall (about 1,500 mm). Annual rainfall amounts gradually decline to about 1,300 mm and the duration becomes shorter and more erratic as you move further inland and beyond the Eastern Guinea Forest zone. Trees become sparse and eventually predominantly grassland as the Guinea Forest-Savanna Mosaic zone changes to West Sudanian Savanna and the rainfall (less than 1,100 mm) becomes even shorter in duration and unimodal. These rainfall and vegetation trends are also accompanied by a general decrease in human population density, development, and food crop production.

While cocoa and oil-palm crops dominate the wetter Guinea Forest ecological zone, maize, millet, sorghum and groundnuts are mostly cultivated in the Savanna zone and cassava performs better in the Guinea Forest-Savanna Mosaic zones, which lies between the Forest and Savanna zones (FAO 2005). However, Bugri (2008) reveals from studying the northeastern part of the Savanna zone in Ghana that most farmers are deeply concerned about poor soil fertility, poor rainfall, plant disease, pests, inadequate land and lack of access to financial resources.

By far the West Sudanian Savanna zone, with dry low grassland, has the most poorly developed district in terms of incidence of extreme poverty. On the other hand, the Guinea Forest-Savanna Mosaic zone is characterized by a composite of economically vibrant districts (ports, harbors, industries and political and commercial headquarters). The Eastern Guinea Forest zone has the prime cocoa, timber and mineral producing districts. In particular, the Wassa West district in this zone contains about 44% of Ghana's closed forest and accounts for 30% of the country's gold production, about 39% of cocoa, 50% of standing commercial timber and 100% of manganese and bauxite production (Akabzaa and Darimani 2001). This natural resource potential provides the basis for varied economic activities in this area. Outside the town of Tarkwa (capital of the Wassa West district) and in rural settlements, subsistence and commercial farming are the main economic activity, but more recently, mining has overtaken farming as the single largest economic activity in the area.

Akabzaa and Darimani (2001) note, however, that there is no effective coordination among institutions regulating mineral extraction in the districts that fall in Eastern Guinea Forest ecological zone. This is reflected in growing encroachment of forest reserve and the resulting conflict between mining companies and displaced communities over compensation in this zone.

Figure 14: Districts by ecological zone in Ghana



Data source: World Wildlife Fund 2010

Method

To examine the relationship between biophysical variables identified above (biomes and ecological zones) and child nutritional outcomes (height-for-age, weight-for-age and hemoglobin), WWF biome and ecological zones data for Ghana were acquired from World Wildlife Fund (2010) and imported into ArcMap 9.3, as was the children data file from the 2008 GDHS. A database operation in ArcMap 9.3 was then used to join the 2008 GDHS child data file to the biome and ecological zones data file. A district map of Ghana was used as the base map in this database operation. This procedure helped to assign each district to a biome or ecological zone with a 60% threshold specification. A 60% threshold was used because it removed ambiguity about which biome or ecological zone a particularly district should be assigned. This procedure was used by Anthamatten (2007) to assign municipalities to biomes in a study of children's nutritional outcome in Bolivia. For the purpose of this study, if 60% or more of a district fell in a particular biome or ecological zone, that district was assigned that biome or ecological zone. This classification method resulted in 76% of spatial units classified into a specific biome or ecological zone and 34% of spatial units unclassified. Once biomes and ecological zones were determined for each district, all children from that district were assigned the characteristics of that biome or ecological zone. Unclassified spatial units were excluded from the analysis because they mostly coincide with the Volta Lake —the largest man-made lake in Ghana. A separate analysis (not shown here) included the unclassified spatial units but did not produce a significantly different result from the analysis that excluded them.

Statistical analysis in SPSS was used to obtain descriptive statistics for each of the nutritional outcomes under study, with respect to the two biophysical variables. Bivariate and multivariate relationships between biophysical variables and children's nutritional outcome were examined with binary logistic regression. Multivariate relationship was examined after accounting for both child level and district socioeconomic variables already discussed above. The results from these analyses are presented in the sections that follow.

Characteristics of Biophysical Variables

Table 18 shows that majority of children (56.5%) reside in the Savanna biome and that the two major biomes —Savanna and Guinea Forest —account for almost 99% of all children. After breaking biomes down into ecological zones, however, the results show that the Eastern Guinea Forest ecological zone hosts most (42.1%) children.

The nutritional profile of children indicates that while children in the Guinea Forest biome are slightly more stunted (24.8%) than children in the other biomes, the most underweight (19.6%) and anemic (80.4%) children are in the Savanna biome. Anemic condition among children in the Guinea Forest biome is however considerably high (79.7%) too. In terms of ecological zones, the results show that children in the Western Sudanian Savanna ecological zone have the worse nutritional outcome across board. Children in the Guinea Forest–Savanna mosaic are however nutritionally better off than their counterparts in the Eastern Guinea Forest ecological zone. Surprisingly, children in the Central African Mangrove performed better on all the nutritional outcomes than children in all the other ecological zones.

Table 18: Biophysical characteristics and child nutritional outcomes in Ghana

Characteristic	N	% of children	% Stunted	% Underweight	% Anemic
Biome					
Savanna	1345	56.5	22.7	19.6	80.4
Guinea forest	1003	42.1	24.8	15.9	79.7
Mangrove	32	1.3	6.3	11.1	70.8
Ecological zone					
Guinea forest-savanna mosaic	521	21.9	16.1	14.0	73.7
Eastern Guinea forest	1001	42.1	24.0	15.9	79.7
West Sudanian savanna	826	34.7	26.9	24.3	85.9
Central African mangrove	32	1.3	6.3	14.3	63.2

Data source: GSS, GHS and ICF Macro 2008; World Wildlife Fund 2010

Bivariate Analysis of Nutritional Outcomes and Biophysical Variables

A binary logistic regression analysis was done to examine whether a significant relationship exists between the biophysical regions identified above and child nutritional outcome (table 19). The results show that residence in the Mangrove biome significantly reduces the odds of stunting among children by a factor of 0.2 (95% CI: 0.050-0.888; p=0.034). The odds of underweight and anemia among children are also reduced but non-significantly compared to children in the referenced biome. Children in the Savanna biome have significantly greater odds of being underweight (OR = 1.3; 95% CI: 1.032-1.618; p=0.025), even though they are non-significantly less likely to be stunted compared to children in the referenced biome.

In terms of ecological zones, residence in the West Sudanian Savanna significantly increases the odds of all but one of the nutritional outcomes considered. For instance while the odds of underweight are significantly increased by a factor of 1.7 (95% CI: 1.333-2.175; p<0.001), the odds of anemia are significantly increased by a factor of 1.6 (95% CI: 1.185-2.036; p=0.001) among children in the West Sudanian Savanna. The odds of stunting also increase but non-significantly among children who reside in the West Sudanian Savanna ecological zone.

However, residence in the Guinea Forest-Savanna Mosaic significantly decreases the odds of stunting and anemia among children by a factor of 0.6 (95% CI: 0.463-0.802; p<0.001) and 0.7 (95% CI: 0.554-0.915; p=0.008) respectively when compared to children in the referenced ecological zone. The odds of underweight are also reduced but non-significantly among children in the Guinea Forest-Savanna Mosaic. Residence in the Central African Mangrove however only significantly reduces the odds of stunting among children by a factor of 0.2 (95% CI: 0.050-0.891; p=0.034).

Table 19: Bivariate analysis of nutritional outcomes and biophysical variables

Variable	β	*SE* β	Wald's χ2	*df*	*p*	*e*β (odds ratio)	95% CI for *e*β Lower	Upper
Stunted								
Biome								
Guinea forest			4.869	2	.088			
Savanna	-.076	.098	.588	1	.443	.927	.764	1.125
Mangrove	-1.557	.734	4.499	1	.034	.211	.050	.888
Ecological zone								
Eastern Guinea forest			25.204	3	.000			
West Sudanian savanna	.153	.108	2.014	1	.156	1.165	.943	1.440
Guinea forest-savanna mosaic	-.495	.140	12.461	1	.000	.609	.463	.802
Central African mangrove	-1.554	.734	4.482	1	.034	.211	.050	.891
Underweight								
Biome								
Guinea forest			5.916	2	.052			
Savanna	.257	.115	5.000	1	.025	1.293	1.032	1.618
Mangrove	-.413	.620	.443	1	.506	.662	.196	2.230
Ecological zone								
Eastern Guinea forest			31.544	3	.000			
West Sudanian savanna	.532	.125	18.192	1	.000	1.703	1.333	2.175
Guinea forest-savanna mosaic	-.145	.144	1.009	1	.315	.865	.652	1.148
Central African mangrove	-.125	.631	.039	1	.843	.883	.256	3.039
Anemic								
Biome								
Guinea forest			1.406	2	.495			
Savanna	.042	.113	.137	1	.711	1.043	.836	1.301
Mangrove	-.483	.458	1.109	1	.292	.617	.251	1.515
Ecological zone								
Eastern Guinea forest			34.902	3	.000			
West Sudanian savanna	.440	.138	10.172	1	.001	1.553	1.185	2.036
Guinea forest-savanna mosaic	-.340	.128	7.048	1	.008	.712	.554	.915
Central African mangrove	-.831	.484	2.945	1	.086	.436	.169	1.125

Data source: GSS, GHS and ICF Macro 2008; World Wildlife Fund 2010

Multivariate Analysis of Nutritional Outcomes and Biophysical Variables

All variables from the child and district levels as well as biophysical variables were combined in separate analyses of the three nutritional outcomes under consideration. The aim was to examine how much additional variation in nutritional outcome is explained by biophysical variables, after controlling for all the other variables previously examined. The results from the analyses show that after controlling for all other variables, the biophysical variables did not offer any additional explanation for the variation in underweight and anemia among children in Ghana. This conclusion was reached because none of the biophysical variables was retained in both models (not shown). A plausible explanation may be that other variables are masking the effects of the biophysical variables on these nutritional outcomes and further studies are required to understand the dynamics at play.

Table 20 below however shows that the ecological zone of residence of a child is an important factor for stunting among children. After controlling for all other variables, the odds of stunting are significantly reduced by a factor of 0.7 (95% CI: 0.514 —0.996; p=0.048) among children in the Guinea Forest-Savanna Mosaic compared to children in the Eastern Guinea Forest. Also residence in the Central African Mangrove significantly reduces the odds of stunting by a factor of 0.2 (95% CI: 0.049 —0.9231; p=0.039) compared to the referenced ecological zone. The coefficients of all the other variables retained in this model also changed slightly from the previous model that combined child and district level variables (table 11 above). This shows that adding the ecological zone variables affected the influence of these variables in the model.

Table 20: Logistic regression model for stunting with biophysical variables

Variable	**β**	**SE β**	**Wald's χ2**	**df**	**p**	**eβ (odds ratio)**	**95% CI for eβ**	
							Lower	**Upper**
Constant	-3.879	.524	54.769	1	.000	.021		
Child's age (months)								
0-12*			51.499	3	.000			
13-24	1.629	.244	44.429	1	.000	5.097	3.158	8.229
25-36	1.367	.252	29.369	1	.000	3.924	2.393	6.434
>36	1.616	.234	47.783	1	.000	5.034	3.184	7.961
Months of breastfeeding								
Breastfed < 6 months*			12.214	2	.002			
6 —24 months	.851	.329	6.677	1	.010	2.343	1.228	4.469
> 24 months	1.236	.363	11.560	1	.001	3.441	1.688	7.014
Health insurance (Yes)	-.516	.124	17.375	1	.000	.597	.468	.761
Wealth index								
Richest*			8.450	4	.076			
Poorest	.558	.337	2.738	1	.098	1.746	.902	3.381
Poorer	.704	.333	4.477	1	.034	2.022	1.053	3.881
Middle	.335	.338	.983	1	.321	1.398	.721	2.708
Richer	.266	.341	.610	1	.435	1.305	.669	2.546
District variables								
Population density	-.733	.312	5.508	1	.019	.480	.260	.886
rural	.006	.004	2.249	1	.134	1.006	.998	1.014
Biophysical variables								
Eastern Guinea Forest			7.881	3	.049			
West Sudanian Savanna	-.060	.146	.168	1	.682	.942	.708	1.254
Guinea Forest-Savanna Mosaic	-.335	.169	3.923	1	.048	.715	.514	.996
Central African Mangrove	-1.548	.749	4.273	1	.039	.213	.049	.923

Test	**χ2**	**df**	**p**
Model fit test			
Omnibus	291.631	15	0.000
Hosmer & Lemeshow	10.394	8	0.238

Note. Cox and Snell R^2 = .129. Nagelkerke R^2 (Max rescaled R^2) = .199. -2 Log likelihood = 1922.805. Overall percentage predicted = 78.2%. All statistics reported here use 3 decimal places in order to maintain statistical precision.

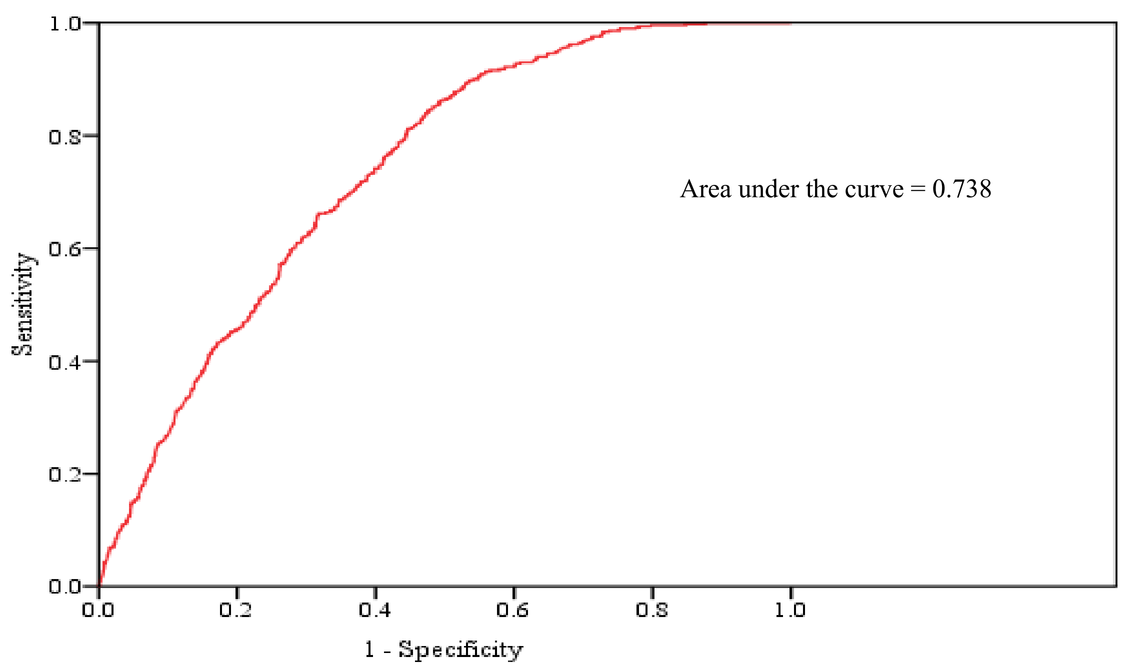
Data source: Ghana Statistical Service 2005; GSS, GHS and ICF Macro 2008; World Wildlife Fund 2010

*Reference group

Model Evaluation for Stunting with Biophysical Variables

This model is overall significant (χ^2 (15) =291.631, p<0.001) and slightly improves upon the previous model (table 11). In particular, the Nagelkerke R Square indicates that this model explains about 20% of the variation in stunting compared to 19% in the model without ecological zones. Moreover the -2 Log likelihood statistics decreases further from 1932.544 in the model without ecological zones to 1922.805 in the current model, which is an indication that this model does better at explaining stunting among the cases examined. Furthermore, this model fits the data as indicated by the non-significance of the Hosmer and Lemeshow goodness of fit (χ^2 (8) =10.394, p=0.238) even though its overall percentage of correctly predicted stunting remains unchanged (78.2%) from the model without ecological zones. Finally, the area under the ROC curve (figure 15) increases slightly from about 73% in the previous model to about 74% in this model. This means that this model will assign a slightly higher probability to stunted children out of all possible pairs of children, one stunted and the other not stunted.

Figure 15: ROC curve and area for stunting with biophysical variables



Chapter 7

CONCLUSION

This study attempts to understand the broad array of factors that shape the nutritional status of children under age five in Ghana, with the view to teasing out those most significantly associated for policy makers and other stakeholders to address in targeting groups of people and places for interventions designed to improve children's nutritional status. Three outcome variables—height-for age, weight-for-age and hemoglobin—were used to measure individual children's nutritional status. Like much previous research, this analysis found a number of characteristics of children and their parents and households (including mother's education and occupation, father's education and occupation, household size and structure, and sanitation) to be significantly associated with children's nutritional status in bivariate analysis. However, these associations were not significant in multivariate analysis.

What distinguishes this study from most research on young children's nutritional status in the Global South is its analysis of data for individual children, made possible by Demographic and Health Surveys (DHS) and assignation of district variables to individual children as cases. This enables assessment of the extent to which characteristics of children, their mothers, their households, the socioeconomic characteristics of the places where they live, and characteristics of the biophysical environment are associated with the children's nutritional status in relation to the other variables.

This chapter presents the key findings of the study and discusses their policy implications. It also describes the study's limitations and suggests areas for future research.

Key Findings

This study is the first to include district socioeconomic and environmental variables at the level of individual children to assess their association vis-à-vis characteristics of Ghanaian children, their parents, and households with those children's nutritional status. The following variables were found to be significantly correlated with at least one of the three outcome measures of nutritional status: child's age, months of breastfeeding, fever (two weeks prior to survey), mother's health status (represented by anemia), prenatal care, mother's occupation, mother's ethnicity, household water supply, wealth quintile, population density, percentage of literate (vs. illiterate) residents in a district, percentage of district residents in rural (vs. urban) locations, wealth status of district residents, and ecological zone of residence.

Characteristics of Children

Consistent with findings from other studies (e.g., Bomela 2009; Colecraft et al. 2004), this study observed that children's age was significantly associated with both stunting and underweight, with children in the 13-24 months age group being most at risk. For instance, after controlling for other characteristics of the child and district variables, the likelihood of stunting among children in this age group was 5.2 times higher than for children ages 0-12 months. Among children ages 25-36 months and those more than 36 months the probabilities were respectively 4 and 5 times higher than for children ages 0-12 months. The chance of underweight occurrence among these children was not as high: 2 times the likelihood for children ages 0-12 months. Children ages 25-36 months and those more than 36 months respectively had about 1.3 times and 0.8 the odds for children ages 0-12months. In contrast, children older than 36 months had a significantly lower likelihood of anemia (OR= 0.5) compared to children ages 0-12 months. As ample published research has shown, the higher probability of stunting and underweight in children ages 13-24 months could be attributed to the challenges of the transition from exclusive breastfeeding or breastfeeding with supplements to more solid foods and drinking water that may be contaminated. Another factor may be children's growing ability to explore their environment and therefore becoming more exposed to infections that compromise their nutritional status.

Contrary to expectation, in this study prolonged breastfeeding was associated with poorer nutritional status. For instance, children who were breastfed for 6-24 months were 2.3 times more likely to exhibit stunting than children breastfed 0-6 months; for children who were breastfed for more than 24 months, the figure was even higher, 3.3 times more likely to be stunted than children breastfed for 0-6 months), after controlling for all other characteristics of the child and district variables (table 11). The figures were even more dramatic for underweight, with children who were breastfed 6-24 months and more than 24 months 3.3 times and 6.3 times, respectively, more likely to be underweight than children who were breastfed 0-6 months (table 14), after controlling for both characteristics of the child and district variables. Studies show that an initial period of exclusive breastfeeding is essential to lower the risk of nutritional deficiency and infectious disease, after which supplementary foods should be appropriately introduced. The current WHO recommendation is worded as follows:

> Infants should be exclusively breastfed for the first six months of life to achieve optimal growth, development and health. Thereafter, to meet their evolving nutritional requirements, infants should receive nutritionally adequate and safe complementary foods while breastfeeding continues for up to two years of age or beyond (WHO 2011c).

The negative association of lengthy breastfeeding with children's nutritional status probably reflects failure of optimal complementary feeding, which may in turn indicate the inability of households to provide supplemental foods (Uthman 2009; Van de Poel et al. 2007) and inappropriate child-feeding practices that could be addressed through education. In Ghana in particular, the practice of feeding young children food purchased from informal street vendors is pervasive in urban areas.

Children who experienced fever in the two weeks preceding the GDHS survey were significantly more likely (2.2 times) to be anemic than children without fever. Interpretation of this association is problematic, in part because infectious diseases that produce fever tend to be seasonal. Furthermore, a child's residence in a wet or dry region results in differential exposure to particular infectious diseases such as malaria. Nevertheless, anemia (a deficiency of hemoglobin in the blood) is the most prevalent micronutrient deficiency globally and compromises both physical and cognitive development in young children. It can be largely ameliorated through iron supplementation in the diet, so identification of groups of children and areas within a country that warrant priority for this intervention is crucial.

Characteristics of Mothers

Although a number of associations between mothers' characteristics and children's nutritional status that were statistically significant in bivariate analysis did not retain their significance in multivariate analysis, two variables did remain significant: anemia in the mother and whether she received prenatal care. Both of these to some extent are likely to represent the economic status of the household and rural vs. urban residence. However, in this analysis, mother's anemia status and prenatal care played an explanatory role beyond that of wealth and urban vs. rural residence. In the final models, mothers' occupation was *not* associated with children's nutritional status, in contrast to research in Malawi that found that children whose mothers worked in a family business or earned wages were better nourished (Chirwa and Ngalawa 2008). The findings of the current analysis are consistent with two earlier studies in Ghana that found no such association (Hong 2007; Van de Poel et al. 2007). In the GDHS data employed in the current survey, slightly more than half of the mothers were either unemployed or worked in agriculture. This means that, unlike formal employment for which mothers have to leave their children with other caregivers, most of these women are able to combine childcare with other tasks.

The results for mother's prenatal care visits were surprising because they defy conventional wisdom. Although the preponderance of evidence indicates that more prenatal care for mothers is good for children's health (for example, see Hong 2006; Janjua et al. 2009; Kandala et al. 2007), this study found that while ten or more than prenatal visits reduced the likelihood of anemia among children by a factor of 0.7 compared to the referenced group (<3 visits), the odds of anemia increased by a factor of 4.3 among children whose mothers had 3-9 prenatal visits, after controlling for children's characteristics and district variables. The wide range in the categorization of number of prenatal visits may have weakened the data, or it could point to the need for more prenatal care visits for women in Ghana if anemia among children is to be effectively tackled. This finding also raises questions about the quality of care these mothers received during prenatal visits.

Mothers' anemia status was significantly associated with children's anemia status in this study after controlling for all other variables including the biophysical environment and rural-urban place of residence. Children whose mothers are anemic are more than twice as likely to be anemic compared to children of mothers who are not anemic. As some studies acknowledge, the mechanism by which this occurs is not very clear but in many malaria proned places in Ghana, mothers and their children who reside in the same households may both have malaria, which can produce anemia. Malaria is most prevalent in the Northern and Volta regions of Ghana.

Household Characteristics

The DHS wealth index variable, which categorizes households into wealth quintile for the survey sample, was significantly associated with all three nutritional outcome variables. Poverty often results in inadequate diet, poor sanitation, greater exposure to pathogens, and low access to vaccinations and basic medical care. This study found that the likelihood of underweight and anemia increased progressively with poverty (i.e., lower quintile for the wealth index), after controlling for all characteristics of children and socioeconomic and biophysical contextual variables. For instance, children in the poorest wealth quintile were 3.6 times more likely to be underweight and four times more likely to be anemic than children in the wealthiest quintile. For stunting, children from the poorer wealth quintile were almost twice as likely to be stunted as children in the wealthiest quintile. The likelihood of stunting among children in the poorest wealth quintile was 1.7 times that for children in the wealthiest quintile.

Other household characteristics significantly associated with children's nutrition status are the "other" category for water supply (comprising tanker truck; cart with small tank; bottled water; and sachet water, which is water that vendors sell in plastic bags). Children whose mothers reported "other" for water supply were less likely to be anemic than children in households with a piped water supply. If water supply indeed offers a partial explanation for anemia status, the mechanism would be its role in protecting children from pathogens. The "other" category for water supply is too broad to pinpoint specific sources of more or less contaminated drinking water. Nevertheless, this intriguing finding points to the need for research that provides a sound assessment of the quality of piped water vs. water from other (specific) sources in Ghana (cf., Dada 2009). Another intriguing finding is that the children in the "other" category for ethnicity were significantly less likely to be underweight than children whose ethnicity was specified (OR = 0.45). No possible explanation for this relationship comes readily to mind.

District Characteristics

The overall picture that emerges from the results above is one that shows that although a number of district socioeconomic variables affect children's nutritional well-being in Ghana, very few are significantly associated. These include the density of the population, percentage of urban and rural residents in a district, percentage of literate and illiterate residents in a district and district wealth quintile.

Although no single factor was significantly associated with all three child nutritional outcomes considered, population density was found to be significantly associated with both stunting and underweight among children in Ghana, while the percentage of illiterate residents in a district and the proportion of a district's population in the poorest wealth quintile showed a significant relationship with underweight and anemia. The impacts of these factors on the nutritional outcomes studied were however mixed. For instance, while the proportion of a district's population in the poorest wealth quintile is significantly associated with less likelihood of underweight conditions, it increases the probability of anemia among children. The percentage of illiterate residents in a district is the only variable that consistently increased the likelihood of underweight and anemia among children in Ghana.

After controlling for all child and district variables, the variables retained in the models include population density, percentage of literate and illiterate residents in a district, percentage of rural residents in a district, and the proportion of a district's population in the poorest and richest wealth quintiles. All of these variables remained significantly associated with the nutritional outcomes considered except population density, which lost its significance in the underweight model. The percentage of rural residents in a district was also barely significantly associated with stunting.

A number of these findings are consistent with previous nutritional studies. For instance, in Nigeria and Bolivia, Folake, Cole and Oldewage-Theron (2008) and Anthamatten (2007) respectively found stunting and under-nutrition to be most prevalent in high density communities. Bawdekar and Ladusingh (2008) also found an inverse but significant association between the percentage of literate females within a district and severe child malnutrition in India. While none of these studies, including the present one, are by themselves compelling, taken together they indicate promising new lines of scientific inquiry that can only lead to improved analysis of children's nutritional well-being.

Biophysical Characteristics

The biophysical environment is another aspect of context that showed significant relationship with children's nutritional outcome in Ghana. Although Anthamatten (2007) found significant relationships between biomes and malnutrition prevalence in Bolivia, this study found no relationship between biomes and any of the nutritional outcomes studied in Ghana, in multivariate analysis after controlling for all child and district socioeconomic variables. This could be due to the different contexts studies but it could also be the consequence of the different analytical methods used. For instance, while Anthamatten (2007) used linear regression models, this study used logistic regression models.

Significant relationships were however observed between ecological zones in Ghana and nutritional outcomes in bivariate analysis. In multivariate analysis, which controlled for all child and district socioeconomic variables however, only stunting showed borderline significance with the ecological zones variable. Children residing in both the Guinea Forest-Savanna Mosaic and Central African Mangrove zones had their respective likelihood of stunting reduced by a factor of 0.7 and 0.2 compared to children residing in the Eastern Guinea Forest. Given the large heterogeneity among socioeconomic groups within districts, it is advisable to interpret these findings with caution but the fact that these categories remained significant after accounting for all other variables in the model indicate that they provide additional explanation for stunting among children in Ghana. Indeed, these findings are consistent with agricultural patterns in Ghana and suggest that children in the heavily forested zones may not be receiving the necessary nutrient and health resources for proper growth.

Child Nutrition Policy

The results show that children's nutritional well-being is associated with a broad range of factors and must be tackled by taking into account not only the immediate characteristics of the children themselves and their households but also the characteristics of the socioeconomic and biophysical milieu of children's residence.

Special attention needs to be given to policies that tackle such critical factors as poverty, illiteracy and access to health care, both at the individual household and district levels. Because these remain the root causes of significant differences in children's nutritional outcome in Ghana. Although the country is currently implementing a school feeding program to target vulnerable children, it is insufficient in the larger scheme of things because the program only addresses the symptoms of nutritional deficit among children in Ghana without dealing with the root causes. It is therefore highly unlikely that the school feeding program would have a sustainable impact in the long term.

Policy makers could include, as an important first step for resource allocation to districts, a benchmark for reducing under-five nutritional deficit. Additionally, targeting public programs towards districts in the central and northern regions could substantially reduce socioeconomic inequality that produces differential nutritional outcomes among children. This is administratively easier than targeting the poor and especially relevant for Ghana, where pro-poor policies (redistribution schemes and exemption policies) have not proven to be effective because of problems with identifying the poor in the first place. Some have recommended geographic targeting to reduce leakage of program benefits to the non-needy compared to untargeted programs (Van de Poel et al. 2007). A potential problem with this approach is that those who are truly needy could end up under-covered. Finding ways of targeting the poor by using smaller geographical units could increase efficiency.

One strategy of the Ghana Growth and Poverty Reduction Strategy for 2006-2009 is to develop and implement high impact yielding strategies for children's nutritional deficit (IMF 2009). This implies targeting areas at the greatest risks of children's nutritional deficit, replicating best practices and expanding coverage. Doing so should go a long way to slow down if not completely eliminate nutritional deficit among children particularly in rural areas and the northern parts of Ghana. The significantly associated characteristics of children, mothers and households as well as the socioeconomic characteristics of districts and biophysical characteristics discussed above could potentially help policy makers in this direction.

There is also a need for scaling up strategies for reducing economic inequality and raising the relative income of the poorest sections of the population. Strategies could include development of relatively poor rural areas; targeting subsidies on consumption; income-based public service for those least able to pay; identifying and tackling the demographic and socioeconomic characteristics of especially poor and vulnerable groups. Beyond income and poverty based strategies, policies should also focus on how to reach the largest number of households and communities with literacy programs and 'other' sources of water as discussed above. Given the significant problem of anemia among children in Ghana, and the significant contribution that 'other' sources of water supply could make to reduce this condition, policy makers can no longer wait to secure large financial outlays to connect households and communities to improved sources of water supply. Simple steps like providing incentives for tanker trucks to extend their coverage could make a lot of difference to children's nutritional outcome in the country.

Limitations

A number of caveats should be considered when interpreting the results of this study. First, the study was based on diverse secondary data, including the Ghana Demographic and Health Survey data (GDHS), the 2000 Ghana Population and Housing Census and World Wildlife Fund (WWF) data, which were collected at different times and not specifically for examining the relationships analyzed here. For instance, while the GDHS data was collected and compiled in 2008, and was designed to collect, analyze, and disseminate socioeconomic and health information, the WWF data was mainly intended for scientific, conservation and education purposes. These problems limit the extent to which these datasets can be reasonably synthesized.

This study can further be criticized for using an indirect measure of househowealth. However, in many developing countries such as Ghana, it is hard to obtain reliable income and expenditure data. An asset-based index is therefore generally considered a good proxy for household wealth status and widely used in poverty based analyses. Household wealth status functions mainly through better access to food and health care in affecting childhood nutritional status, for example more wealthy households can afford better food in terms of quality. Also, this study included variables that were derived from mother responses to questions about whether each child had diarrhea, fever, and cough during the two weeks preceding the interview. These responses are not only imprecise by reason of mothers bias recall, but they also suffer from uncertainty about their shared meaning. Additionally, the infectious diseases for which diarrhea, fever, and cough are symptoms are seasonal and sporadic and data may not have been reported in relation to specific disease outbreaks.

Furthermore, although street foods are an important component of the diet in Ghana, especially among low-income households, this variable was not included in this study because of the unavailability of data. Since little is known about the nutritional quality of street foods and how they affect children's nutritional outcome in Ghana, research on this topic could prove very useful.

Methodologically, an important shortcoming of this study is that although DHS captured the outcome variables as continuous variables, they were treated as dichotomous variables in this analysis. While categorizing continuous variables into a limited number of groups makes it easier to analyze and interpret associations, the downside is that it misses the more nuanced analysis and interpretation of research results offered by linear statistical models. This study is hardly alone in its dichotomous treatment of these nutritional outcome variables (see Bomela 2009; El Taguri et al. 2009; Singh et al. 2009; Sunil 2009).

The downside of logistic regression modeling is that it can be used only to estimate odds ratios in cross-sectional studies and not to predict individual risk. This is however not a problem in this cross-sectional study, which is not intended to predict risk but merely to estimate the probability of a particular nutritional outcome given a set of independent factors. In a different study, Hong and Mishra (2006) carried out a similar analysis using a continuous response variable of height-for-age z-scores and a linear regression model, but the results were similar to those from the binary and multinomial logistic regression models.

From a policy and research perspective, it is noteworthy that the best-fitting models in this study accounted for no more than 26% of the observed variance when all factors are simultaneously examined. Perhaps this is not surprising for a cross-sectional, multilevel analysis of variables that also include district socioeconomic and biophysical factors. It is also consistent with the expected complex interactions between observed factors that are precise (household size, child age, mother's BMI, and so on) and those that are far less precise (mostly due to mother's recall), or those not observed not at all. Often times, factors such as soil fertility, access to markets, availability of adequate and affordable medical care and other spatial variables may influence patterns of poverty and nutritional outcome, but the evidence for such influences are hard to observe. However, what is indisputable is the fact that the empirical foundation for generalizing the relative impacts of such forces is significantly limited by the absence of adequate data, and potentially incompatibilities in the resolutions and units of analysis of the data that do exist.

These potential limitations, notwithstanding, the large size and representativeness of the secondary data used in this study made possible the kinds of statistical analyses conducted here. The consistency in the direction and strength of the relationships established also suggest that reducing socioeconomic inequality and making services more accessible to the poor will be key to improving children's well-being in Ghana. The findings of this study can potentially assist stakeholders with a better understanding of the diverse factors that influence the nutritional needs of children in Ghana.

Future Research

The study of children's well-being has been limited, to a degree, by division into diverse disciplines, with many social scientists focused on individual and household-level factors, nutritionists concerned with hereditary and gender differences and soil and climate scientists fixated on the potential impact of climate and soil on agricultural sustainability and food production. While these diverse scientific fields of enquiry are conceptually linked by, for instance, the UNICEF framework, few studies systematically assess them simultaneously. Although this study attempts to close this gap, constructing dynamic and engaged interdisciplinary research that involves diverse spheres of knowledge would not be an insignificant future undertaking for children's well-being. Such interdisciplinary research and application might pave the way for more holistic interventions in children's well-being in developing countries.

Future research should also address the mechanisms through which childhood nutrition and different environments are connected. Understanding these mechanisms is crucial to the design of district-based interventions because these processes are more amenable to change than entrenched structural properties of communities (e.g. concentrated poverty). Although this study does not investigate these mechanisms, the findings here provide evidence that area effects play a role in children's nutritional outcome—that socioeconomic and biophysical contexts are associated with nutritional outcome beyond individual child-level factors. Scholars trying to understand variations in children's well-being should pay attention to the characteristics of both children and milieu of residence.

Consideration should also be given to the strategies that children, households and communities develop to solve socioeconomic problems that adversely impact children's nutritional outcomes. Children and their families and communities are often constantly required to make choices and be creative, in order to guarantee favorable nutritional outcomes. Understanding the challenges and coping mechanisms that children, their households and communities use can provide important insights into how policy should be oriented to to reap maximum benefits.

Finally, as already observed above, a number of variables, including parental education and occupation, sanitation at both the household and district levels, proximity of residence in districts to hospitals, clinics and schools, and biomes, failed to show significance in the multivariate analysis carried out in this study. Some of these variables have been widely reported to be associated with children's nutritional outcomes different contexts. Future research could explore explanations for the lack of significance with children's nutritional outcomes in the Ghanaian context.

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