The Effect of Maternal Education on Child Stunting in Guatemala

An Honors Thesis for the Department of Economics

Kathryn Taylor

Tufts University, 2011

Table of Contents

Acknowledgements

Special thanks to Edgar Hidalgo of the Universidad del Valle in Guatemala, and to Paul Stupp and Alicia Ruiz of the Center for Disease Control (CDC) in Atlanta, GA for their help with the *Encuesta Nacional de Salud Materna Infantil* (ENSMI) dataset.

I. Introduction

The purpose of this paper is to analyze the causes of chronic malnutrition in Guatemala, focusing on the impact of maternal education attainment on child nutrition status. I focus on maternal education partially because previous studies have demonstrated its importance in terms of improving child health; for instance, an extensive cross-country study produced by the International Food Policy Research Institute (IFPRI) found that 62.3% of the improvement in chronic malnutrition rates in Latin America between 1970 and 1995 can be attributed to higher women's education attainment (Smith and Haddad 2000, 73). However, country-specific analyses of the relationship between maternal education and child health have produced mixed results. Some studies conclude that effect of maternal education on child health can be fully explained by factors such as literacy, access to information, and health knowledge, while others argue that education attainment itself is significant. My analysis of the importance of maternal education on child health will consist of two basic components. The first is a cross-country analysis to examine the determinants of child malnutrition across developing countries, focusing on how Guatemala compares to these other countries. The second is a country-specific study using household level data in Guatemala.

I.1 Country Background

Guatemala is located in Central America, directly south of Mexico, and is divided into 22 departments. For a country of its size, Guatemala has an astounding level of diversity in terms of ethnicity, language, wealth, and geography. It has the highest indigenous population of any country in Central America, at about 40% of the population, and most of the indigenous population speaks one of the 21 Mayan languages that are recognized by the government. The non-indigenous population in Guatemala is referred to as Ladino. The World Bank considers Guatemala a middle-income developing country, and 51% of the population lives below the poverty line. It is also highly unequal, with the richest 10% of the population owning 42.4% of the wealth, and the poorest 10% owning 1.3% (World Bank WDI). In fact, Guatemala is often referred to as an oligarchy, with a handful of wealthy families making a fortune from industries such as rum and sugar. There is a significant distinction between the ladino, urban population, which resides mostly in Guatemala City and its suburbs, and the poor, mostly indigenous inhabitants of the rural areas. Indeed, as a Guatemalan Congressman once remarked, “There are really two Guatemalas, two distinct societies—one that you see in the city, and another in the countryside” (Garcia).

This disparity between the rich and poor, and Ladino and indigenous, populations both caused and was exacerbated by Guatemala’s 36-year civil war, which ended in 1996. The war’s most violent years were in the early 1980s, when tens of thousands of people were massacred and 400 indigenous villages were completely destroyed (Guatemala | Idex). Since the end of the civil war, violence in Guatemala has shifted from rural to urban areas with the growing influence of narco-trafficking gangs.

I.2. Malnutrition in Guatemala

Guatemala has the 4th highest rate of chronic malnutrition in the world and the highest rate in the Western Hemisphere, with 49% of children under the age of 5 exhibiting a height-for-age z-score less than two standard deviations below the WHO mean (ENSMI 2008/9). This stunting rate is much higher than its Central American neighbors (see Figure 1), though these countries have similar social and economic climates. Chronic malnutrition is characterized by long-term micronutrient deficiencies and suboptimal caloric intake, and it increases susceptibility to disease and profoundly affects physical and cognitive formation, which impacts both individual welfare and society-wide productivity and development. The effects of malnutrition are permanent after the first 2-3 years of life and a number of studies have found a link between childhood malnutrition and cognitive impairments throughout adolescence, adulthood, and old age (see, for instance, Glewwe and King 2001). While Guatemala has readily adopted micronutrient fortification programs, these programs have been largely ineffective because of poor implementation, so Guatemalans receive very little iodine-fortified salt or folic acid-fortified flour. Only 16% of children surveyed in the 1999 Demographic Health Survey had an adequate daily caloric intake and 2% received recommended levels of dietary iron in 1999, though most children did consume enough Vitamin A (Marini 2003, 3).

In addition to the problem of chronic malnutrition, Guatemala has also recently faced food shortages that have caused an increase in acute malnutrition, or calorie deficits that result in wasting (low weight for height). The recent food crisis has affected the southeastern part of Guatemala and began in the summer of 2009, when a severe drought reduced crop yields and pushed up food prices. The crisis worsened in 2010, when flooding brought by ten back-to-back tropical storms in four months again severely decreased crop yields. This recent food crisis has received considerable attention in the Guatemalan news and has even been publicized in international media, and NGOs and multilateral agencies have dedicated millions of dollars in aid. However, acute malnutrition still only affects a small percentage of the population, while chronic malnutrition is a much more pervasive problem that has received much less attention.

I.3. Maternal Education and Child Nutrition: Underlying Mechanisms

There are multiple mechanisms through which maternal education attainment affects child nutrition. Broadly speaking, child health is determined by three factors: direct health and nutrition inputs provided by the parents (or household), the local and household health environment, and the individual child's unobserved health endowment (genetic factors). Maternal education can affect the first two of these determinants of child health in a number of ways. First, schooling may increase earning potential and household income, providing women with more resources for childcare. Next, literacy and numeracy skills learned in school enable women to manage the household more effectively and take advantage of programs and resources to benefit their children. Schooling also affects child health through its impact on maternal health knowledge. Formal schooling may impart health knowledge that pertains to child rearing, such as learning about the importance of various micronutrients and how they are obtained in the diet. Additionally, literacy and numeracy skills allow mothers to improve their health knowledge over time. Schooling may also change a mother's views towards traditional medicine and make women more likely to utilize modern health care practices. Finally, women with more education may have a higher level of autonomy, which could, for instance, allow them more control over their fertility preferences.

Glewwe (1999) presents a mathematical model that decomposes the effect of maternal schooling (MS) and child health (H):

$$\frac{H_i}{MS_i} = \frac{H_i}{L_i}\frac{L_i}{MS_i} + \frac{H_i}{N_i}\frac{N_i}{MS_i} + \frac{H_i}{V_i}\frac{V_i}{MS_i} + \frac{H_i}{Y_i}\frac{Y_i}{MS_i} + \frac{H_i}{HK_i}\left(\frac{HK_i}{MS_i} + \frac{HK_i}{L_i}\frac{L_i}{MS_i} + \frac{HK_i}{N_i}\frac{N_i}{MS_i}\right)$$

The first four terms on the right side of the equation represent maternal education's impact on child health through literacy, numeracy, values, and income. The final term represents maternal education's impact on health knowledge, which is also affected by the literacy and numeracy skills gained in school. In this model, "values" captures an array of factors, including fertility preferences, autonomy, and attitudes towards modern health care.

I will elaborate on the pathways through which maternal schooling affects child health in the Literature Review section, where I present various studies that empirically test these various pathways.

I.4. Stunting as a Measure of Chronic Malnutrition

Throughout this paper I will use stunting (height for age) as a measure of chronic malnutrition for children under the age of five. Stunting reflects a wide range of factors throughout a child's life, including dietary intake, past illnesses, mother's height, and mother's diet during pregnancy. There are other ways to measure more specific malnutrition outcomes, such as analysis of biomarkers in hair, blood, or urine or stress and respiration tests. However, such tests are quite costly so data can be collected only from small populations. Stunting is a general measure that cannot, for instance, reflect outcomes such as specific micronutrient deficiencies. It is useful to instead think of stunting as an indicator of the general, long-term health of a child.

II. Review of the Literature

There have been a number of studies that aim to determine the causes of child stunting using both cross-country and household-level data. Below I review a selection of papers that examine the pathways through which maternal education affects child health. First, I will review two cross-country studies that examine the impact of national variables on the prevalence of child malnutrition in developing countries.

II.1. Cross-Country Comparisons

Cross-Country Studies

Smith and Haddad (2000) present a comprehensive cross-country analysis of the determinants of child underweight status using data from various sources, including the WHO, FAO, and UNICEF databases. The study relies upon the United Nations Children's Fund (UNICEF) Framework for the causes of child malnutrition, examining the immediate determinants (dietary intake and health status) and underlying determinants (food security, adequate maternal care, and adequate health environment) of child nutrition status. Instrumental variables are used to account for endogeneity problems in cross-country malnutrition studies. The report finds evidence that the quality of a country's health environment, women's education attainment, women's relative status, and national food availability are strong determinants of child underweight status.

Smith and Haddad also examine the principle causes of the decline in child malnutrition between 1970 and 1995 using fixed effects parameter estimates. They find that improvements in maternal schooling attainment can explain most of this decline in malnutrition, though improvements in national food availability, health infrastructure, and women's status also contributed. The report also examines the strength and potential impacts of each independent variable to determine priority areas for each region in terms of reducing malnutrition. According to these estimates, Guatemala would benefit substantially from improved food availability, and as a region Latin America and the Caribbean would most benefit from an improvement in women's education and relative status.

Similarly, Milman et al (2005) study the cross-country determinants of child stunting as well as the causes of improvements in child height in the developing world. This study uses the same basic model as the Smith and Haddad report, but adds variables such as HIV/AIDS prevalence, public health expenditures, government consumption, value added in agriculture, official development assistance, external debt, and income distribution. The researchers run nine different multiple linear regression models to determine the most accurate and parsimonious model. However, this study does not address the problem of endogeneity in the modeling. Endogeneity can result from multiple sources in cross-country studies of malnutrition, including reverse causality between malnutrition and explanatory variables (such as health infrastructure or official development assistance) or unobserved and highly correlated characteristics such as cultural values.

Surprisingly, Milman et al find that improvements in safe water were associated with higher rates of stunting. Unlike the Smith and Haddad study, level of democracy is found to be insignificant in the present study. Significant variables include income inequality, with higher levels of inequality associated with greater rates of stunting.

Increases in immunization rates and high rates of female literacy are associated with lower rates of stunting.

II.2. Guatemala-Specific Analysis

Maternal Education and Child Health

While some country-specific studies find a strong, negative association between maternal education attainment and child malnutrition, others conclude that this association can be explained entirely by factors such as household wealth and nutrition knowledge. Below I will present studies that empirically test four pathways through which maternal education affects child nutrition: household wealth, nutrition knowledge, health care utilization, and female autonomy.

Defo (1997) uses data from the Survey of Child and Infant Mortality in Cameroon to examine how socioeconomic factors affect maternal health. The dependent variable in the study is a composite variable of women's incidence of illness in the previous two years. While this is obviously not a direct measure of a child's health, the mechanism through which maternal education affects the mother's health is presumably analogous to the relationship between education and child's health. After controlling for employment status, geography, and sanitation, Defo finds that maternal education does not have a significant effect on maternal health. Instead, Defo argues, education's impact on health status can be explained entirely by socioeconomic status, which increases purchasing power for acquiring health services and nutritious food.

Block and Webb (2004) use data from a household survey in central Java to examine the impact of maternal health knowledge on malnutrition. The survey was conducted in households that had been targeted in a nutrition awareness campaign, and nutrition knowledge is proxied by how accurately women can list the benefits of Vitamin A. They find that the impact of maternal schooling on child health is nuanced; schooling has no impact independent from nutrition knowledge on short-term nutrition outcomes (weight for height), but is significant for long-term nutrition outcomes (height for age). They conclude that while specific nutrition knowledge is more useful in minimizing the detrimental effects of health shocks, maternal schooling rather than specific health knowledge is a more important determinant of stunting.

Bicego and Boerma (1993) use DHS data from 17 developing countries, including Guatemala, to examine the impact of maternal education on child morbidity and nutrition (underweight). They specifically examine the link between maternal education and health care use, with non-use of tetanus toxoid vaccination during pregnancy and non-use of antenatal care used as proxies for health care utilization. Bicego and Boerma find that the relationship between education and tetanus vaccination use varies by country, and the gross association in Guatemala is almost nonexistent. In contrast, the effect of maternal education on non-use of antenatal care is significant in Guatemala after controlling for household economic characteristics: women with secondary education attainment are about four times more likely than non-educated women to receive antenatal care. The effect of secondary education (relative to no education) on underweight status after controlling for economic factors and health care use is still significant in Guatemala, though not for other countries in the sample.

Doan and Bisharat (1990) examine the link between female autonomy and child health in Jordan using a Health and Population Assessment in four urban areas of

Amman. The researchers take advantage of the rigid social hierarchy in Jordanian society to analyze female autonomy; for instance, a young mother must defer to both her husband and mother-in-law. A child's weight-for-age is used as an indicator of health (information on height was not collected), and the researchers compare the nutritional outcomes of households in which the mother is a head or co-head to households in which her mother-in-law resides. Doan and Bisharat find that a low level of maternal autonomy significantly and negatively affects child nutrition status after controlling for income, geography, mother's education, and household demographics. However, mother's secondary education attainment remains significant after controlling for autonomy. The researchers conclude that low maternal autonomy lowers "maternal bargaining power" on behalf of her children, which negatively affects the children's health (Doan and Bisharat 788).

Frost, Forste and Haas (2005) investigate the specific links between women's education and child health using DHS data in Bolivia. The researchers test the major hypotheses discussed above: socioeconomic status, knowledge, attitudes, female autonomy, and reproductive variables. They conclude that socioeconomic status is the primary pathway linking maternal education and child health (accounting for 50% of the effect), but modern health care utilization and health knowledge are also significant, accounting for another 15% of the total effect. The effects of the reproductive variables are small but statistically significant, while the female autonomy index is not statistically significant. However, the researchers find that maternal education attainment remains significant after controlling for all of these pathways in the full model, suggesting that maternal education has unexplained effects beyond those tested in this study. Frost, Forste, and Haas note that the remaining significance of maternal education may also reflect measurement error, especially as the DHS does not provide specific information on income or female autonomy.

Given Guatemala's large indigenous population, I am also interested in looking at the impact of indigenous status and language on malnutrition. Using DHS data from Bolivia, Morales et al (2004) examine the impact of culture and geography on child nutrition status. To examine the impact of indigenous status on child health indicators, researchers include dummy variables for speakers of Quechua and Aimara, two indigenous languages in Bolivia. The study finds that the children of Quechua mothers have poorer health than other Bolivian children, and this effect decreases but is still significant after controlling for maternal anthropometric characteristics and maternal education. Interestingly, the Aimara language dummy variable is not significant after controlling for these factors. The researchers do not present any explanations for this effect, but note that additional research should be conducted. Mother's education, child age, altitude, and household assets are additional significant variables.

Studies Conducted in Guatemala

While there are no studies that specifically examine the relationship between maternal education and child health in Guatemala, there have been a number of studies that examine the determinants of child malnutrition. These studies generally find maternal and paternal education, ethnicity, language ability, and household sanitation and demographics to be primary determinants of child malnutrition.

Seeraburta et al (2006) conduct an intensive study of two villages in Guatemala to determine the impact of *Giardia Lamblia* infection and various household characteristics on stunting. The researchers examined 131 children aged 30 to 80 months, testing children for *Giardia* infection and collecting household, environmental, and demographic information using questionnaires. Researchers found that illiteracy of the primary caretaker, household size (>4 children), unsafe drinking water source, and unsanitary waste disposal are the only statistically significant determinants of stunting.

Gragnolati (1999) uses data from the *Encuesta Guatemalteca de Salud Familiar* (Guatemalan Survey of Family Health) to identify the community and family-level determinants of poor child health in Guatemala. Gragnolati utilizes the Mosley-Chen analytical framework, which identifies five broad types of proximate determinants of child health in developing countries: 1. Maternal fertility (factors affected by reproductive practices, including age at childbearing and birth interval); 2. Environmental contamination with infectious agents (influenced by hygienic practices); 3. Nutrient deficiency (affected by feeding practices); 4. Injuries (influenced by care); and 5. Personal illness control (affected by health care practices). This study finds ethnicity, per capita expenditures, non Spanish-speaking, maternal and paternal education, and presence of health infrastructure in the community to be significant determinants of stunting. Interaction variables between education and health infrastructure are also significant, suggesting that parents with more education are able to benefit more from provision of health services.

III. Data Description

The data utilized for this study stem from multiple sources. For the cross-country analysis, I will use a dataset that combines nutritional outcomes from every Demographic Health Survey (DHS) undertaken in a twenty-year span, from 1986 until 2006. These data are combined with country-level indicators gathered from a range of sources, mostly the statistical databases of various UN organizations. To conduct an in-depth analysis of the determinants of chronic child malnutrition specifically within Guatemala, I will be using surveys carried out by the Guatemalan government's Secretariat of Nutrition and Food Security in five different years.

III.1. Cross-Country Analysis

The malnutrition data of the cross-country analysis are derived from a compilation of the DHS surveys conducted from 1986 until 2006. All rounds of surveys from DHS I, DHS II, DHS III, and DHS+ were used, representing 53 developing countries around the world for a total of 130 observations. A list of countries and survey years can be found in Table 1. Bhagowalia (2008) compiled the nutrition information in these surveys to create the height for age (HAZ), weight for age (WAZ), and weight for height (WHZ) indicators using Stata. The dependent variable in my cross-country analysis is the prevalence of stunting reported for each country in a specific year, where prevalence is defined as the percent of the population with a HAZ lower than two standard deviations below the World Health Organization reference population. I have supplemented these data with other country indicators, including GDP per capita (*gdppc),* water availability (*watraval),* food availability (*foodaval),* and average female schooling attainment (*yr_sch*) as well as regional dummies. Descriptions of these variables and summary statistics are provided below, and summary statistics and sources for these variables can be found in Table 2.

HAZ

HAZ represents the percentage of the population with a height-for-age z-score that is more than two standard deviations below the WHO mean. The maximum value of *HAZ* in this sample is found in Guatemala at 62.36% in the year 1987.

FOODAVAL

The variable *FOODAVAL* represents daily per capita dietary energy supply in each country for the given year. These measures are derived from trade and production data and compiled by the Food and Agriculture Organization (*FAOSTAT* 2009). The FAO estimates a supply account detailing the weight of each commodity using data on factors such as seed rates and animal feed, and these weights are then converted into energy values. These aggregated energy supply estimates are divided by the population to arrive at the per capita value.

GDP

GDP represents GDP per capita in PPP-adjusted, 2005 US dollars. The data are from the World Bank's *World Development Indicators* (World Bank 2008). PPP-adjusted measures are used to reflect buying power in different countries due to variations in local prices of non-tradable goods.

GINI

The Gini coefficient is the standard measure of inequality, with a value of 0 representing perfect equality and 1 signifying perfect inequality. This indicator will control for the distribution of GDP per capita to reflect a more accurate portrayal of the level of poverty within each country.

YR_SCH

Years of female schooling for the population over the age of 15 (*YR_SCH*) are used to measure maternal education attainment. This data comes from the Barro-Lee (2010) dataset on worldwide education, which contains various measures of education attainment for males and females for every five years. The data come from various sources, including census data, UNESCO, and Eurostat. Barro and Lee extrapolate from previous survey results to contend with missing observations. I round the panel years in my compiled DHS dataset to the closest 5-year interval to merge with the Barro-Lee education dataset.

WATRAVAL

Water availability (*WATRAVAL*) is defined as the percentage of the population with access to adequate safe water, and this information is gathered from multiple World Health Organization (WHO) surveys. Adequate water is defined as the amount of water required to carry out basic metabolic, hygienic, and domestic tasks—according to WHO (1997) about 20 liters a day. Water availability in this case is used to proxy each country's health infrastructure, including sanitation and access to health care. However, there are significant concerns with the use of this indicator, as the definitions of both "access" and "safe water" vary across countries and years.

LERATIO

The variable LERATIO represents the ratio of female to male life expectancy at birth, which is used in this context as a proxy for women's status relative to men's. Women's relative status is difficult to measure, but a biased life expectancy ratio in favor of men can represent long-term, entrenched discrimination against women. Because women have a biological advantage in the aging process (in part because of their additional X chromosome that protects against harmful mutations as well as the presence of female hormones), a ratio closer to one reflects a lower societal status of women while a higher ratio suggests a higher social status.

III.2. Guatemala-Specific Analysis

The data used for the study of determinants of chronic child malnutrition within Guatemala is derived from the National Survey of Maternal and Infant Health (ENSMI by its Spanish name). In 1987, 1995, and 1998-1999 the ENSMI surveys were conducted in conjunction with the DHS surveys, while the 2002 and 2008-2009 ENSMI were carried out independently by Guatemala's Ministry of Public Health and the Secretariat for Food Security and Nutrition (SESAN). Surveys are then processed with the assistance of the Center for Disease Control (CDC) in Atlanta, GA. All of these surveys include anthropometric results for children between 3 and 59 months of age as well as other health data and basic household characteristics, which include parental education attainment and literacy, household size, ethnicity, geographic area, and language spoken in the home.

Survey Methodology

The survey population targeted by all five surveys was designed to reflect the population demographic information of the most recent census available for each year.

The surveys were conducted in Spanish as well as four of the major indigenous languages: Quiché, Cakchiquel, K'echí, and Mam. Sample sizes of the various surveys range from 2,106 households in 1987 to 7,489 in 2008/9 (see Table 3 for the sample sizes in terms of household and children for each survey). There are minor discrepancies among the various surveys. Most notably, the 1987 survey includes anthropometric nutrition information for children under the age of 3, while the four later studies include this information for children under the age of 5.

There are also variations in the information collected in the various surveys. For instance, the 1987, 2002, and 2008 questionnaires included a question regarding paternal literacy, while the 1995 and 1998/9 did not. Similarly, beginning in 1998/9 the Petén region in the north was added as a geographical area, but was not included in 1987 or 1995. To ensure consistency across data from the various surveys, I use the "lowest common denominator" for some indicators. For example, categorical definitions of the toilets used by household members vary across survey years. While some surveys individually record specific toilet types, others include facilities such as latrines and "blind holes" or wells in the same category, though these terms encompass a wide variety of sanitary conditions. However, the lack of specificity in some of these surveys necessitates these broad groupings. Tables 3 and 4 include the summary statistics and distributions, respectively, of the continuous and binary variables.

IV. Methodology

IV.1. Cross-Country Analysis

The inclusion of more than one observation year for each country presents the opportunity to control for unobserved time-invariant and country-specific factors that affect child stunting. These factors could include unobservable characteristics such as cultural feeding patterns or climactic variations. To control for this unobserved heterogeneity, a Fixed Effects (FE) model can be used. The basic FE model is as follows:

$CM_{it} = a + X_{it}b + v_{it}$, (1)

where CM is the nutrition prevalence in a given country and X is a vector of the country indicators described in the previous section. The time-invariant error term is eliminated through differencing in the FE model, and v_{it} is the remaining stochastic error term. I will compare the FE results with the results from the Random Effects (RE) model, and will perform a Hausman test to determine which of these models should be used.

Endogeneity Concerns

Endogeneity, or correlation between the explanatory variables and the error term, is of particular concern for cross-country studies of malnutrition. While indicators such as access to safe water can be considered exogenous when using household or individual-level data, national indicators reflect the attitudes, motivations, and choices of policymakers that independently affect child health status. Some cross-country studies use the Hausman-Wu Instrumental Variables (IV) test for endogeneity of the explanatory variables, but the instruments tend to be implausible. For instance, in the Smith and Haddad cross-country study, the candidate instruments for female secondary school enrollment rates include education expenditures as a percent of GDP and secondary school teachers per capita. However, these measures could very well independently impact child nutritional status as they reflect the quality of a country's education system.

Because the FE model differences out the time-invariant error term, using the FE eliminates the possibility of endogeneity for factors that remain constant throughout the survey years, leaving only the possibility for time-variant, within-country endogeneity. While it seems relatively unlikely that the underlying country-specific climate described above would change significantly in the 15-year span of these surveys, it is possible that remaining endogeneity could bias the estimates produced by the FE model.

IV.2. Guatemala-Specific Analysis

The Impact of Maternal Education on Child Stunting

In this study, I will determine the specific pathways through which maternal education impacts child nutritional outcomes. Using the individual-level data from the DHS described in the previous section, I will focus on two primary pathways associated with child health: socioeconomic status and health knowledge. The dependent variable in this study is *MALN,* the dichotomous variable that equals 1 if the child exhibits an HAZ less than -2, and 0 otherwise. I will first regress *MALN* on three binary variables representing primary, secondary, and tertiary education attainment to determine the uncontrolled education effects. The second model will include geographic controls, and the third and fourth represent the socioeconomic and health knowledge pathways, described in more detail below. The fifth regression will include the full model.

Socioeconomic Status

Because the DHS survey does not include information on income, I will use three different indicators to measure socioeconomic status. The first is an index of household characteristics, including the presence of a flush toilet, piped water, electricity, and a nondirt floor. The second is an index of household wealth, which includes owning a television, radio, refrigerator, and phone. The third is paternal education attainment, which is included as an economic indicator because it is correlated with household income but should not otherwise affect child health status, as men are not the primary caretakers of the children in Guatemala.

Health Knowledge

To assess health knowledge, I created a health knowledge index that includes if a woman has heard of AIDS, if she has heard of modern methods of contraception, if she knows when in her ovulatory cycle she can become pregnant, and if she has heard of Oral Rehydration Therapy (ORT) for diarrhea. I also include the duration of breastfeeding without the introduction of complementary foods (which is recommended until at least six months by the WHO and UNICEF). A binary variable representing literacy is also included in this model, as a woman who is literate, even if she has no schooling, has a greater chance of receiving and interpreting heath messages and making informed choices regarding health and nutrition than an illiterate woman. Spanish language ability is included in this model as well for similar reasons.

It is important to note that health knowledge could be endogenous, in this case correlated with a child's unobserved health endowment. This is because parents with sickly children will, ceteris paribus, acquire more health knowledge than parents with healthy children. Three of the four components of my health knowledge index would not be affected by endogeneity (assuming that knowledge of AIDS, contraception, and awareness of ovulatory cycle are uncorrelated with child's health endowment). However, knowledge of ORT for diarrhea is very likely correlated with the child's health endowment. With this potential endogeneity, it is possible that the coefficients will underestimate the impact of health knowledge on decreasing the likelihood of stunting.

Indigenous Status

I will also include indigenous status in the full model to determine the effect of ethnicity after controlling for maternal education, literacy, and Spanish ability. Including ethnicity also serves as an indicator of the health attitudes of individuals. Pebley, Goldman, and Rodriguez (1996), in a study of prenatal care and child immunizations in Guatemala, found that Spanish language ability and ethnicity were significantly associated with health care utilization with indigenous and non-Spanish speakers less likely to utilize health care. The relationship between ethnicity and attitudes towards health is particularly interesting as common belief among the middle and upper classes in Guatemala, including many of those who work in public health, holds that eating unhealthy foods and stubbornness regarding nutrition and modern medicine is simply an unchangeable part of indigenous culture and that child malnutrition is thus inevitable among the indigenous population. However, lacking other indicators in the data, ethnicity serves as a crude measure of health attitude.

Estimation Strategy

Because the dependent variable (*MALN*) is dichotomous, taking on a value of 1 if the child has a HAZ less than -2 and 0 otherwise, I will use a logit regression model for this part of my study:

$$\text{logit}(p)=b_0+b_1X_1+\ldots+b_nX_n, \text{ where } \text{logit}(p)=\ln\left[\frac{p}{1-p}\right] \quad (6)$$

Missing Variables

As mentioned in the previous sections, there are some indicators with missing values, most notably in the Guatemala-specific study as some indicators are missing for entire years due to survey variation. To contend with this, I generate a binary "missing value" variable flag so the observations containing missing values are still included in the results.

V. Econometric Results

V.1. Cross-Country Analysis

Table 5 shows the results using the 130-observation, 53-country sample for the Random Effects (RE) and Fixed Effects (FE) models (dependent variable is *HAZ*). As shown, the only two indicators that significantly ($p<.01$) affect the prevalence of malnutrition in the RE model are average female schooling attainment and GDP per capita. However, in the FE model only female schooling attainment is significant ($p<.01$). I conduct a Hausman test, which tests for correlation between the country-specific error terms and the regressors, to determine if the RE or FE model is preferred. The null hypothesis that the RE model is efficient and consistent is rejected with a p-value of .123. The discrepancy between the significance of the coefficients in these two models therefore suggests that the significance of *gdp* in the RE model is correlated with unobserved country-specific factors that affect malnutrition, and these results are therefore biased.

I will explore two potential causes for the absence of significant results other than female schooling attainment in the FE model: multicollinearity, or high correlation among the independent variables, and lack of variation in the dependent variable within countries in the panel set. The correlation matrix of the variables, found in Table 6, shows that the absolute values of correlations are relatively low, not exceeding 0.65 for any of the variables. I also check for multicollinearity by regressing each of the independent variables on the remaining variables, but with none of the R-squared values exceeding 0.6, I conclude that high correlation among the regressors cannot explain the lack of significant results.

To examine if there is limited variation within countries, I regress the dependent variable (*haz*) on the 53 country dummy variables. The R-squared for this regression is 0.92, meaning that 92% of the variation in the dependent variable comes from cross-country variation, leaving only 8% that can be explained by within-country variation. Because identification in the FE model is based on within-country variation in the explanatory variables, this lack of variation in the dependent variable constricts the model's ability to capture significant results. However, the RE model similarly produces only two statistically significant results: *gdp* and *yr_sch*. This suggests that in addition to this lack of within-country of variation, both models are constrained by a high level of unobserved variation among countries.

Though this analysis is limited by lack of within-country variation in addition to unobserved variation among countries, one robust conclusion drawn from these results is the importance of female education as a cross-country determinant of stunting prevalence. Female schooling attainment is the only variable that remains statistically significant after controlling for unobserved time invariant and country-specific factors, and with an elasticity of -45%, its effect is substantial.

I will now examine how well these models explain the high rates of stunting within Guatemala. Guatemala has the highest fixed effect of the 53 countries at 19.15, with the second highest residual found at 17.14 in Gabon. However, this high residual could be partially explained by the fact that Guatemala has the highest stunting rates overall, at 62% in 1987. To account for this, I create a standardized fixed effect by dividing the original fixed effect by each country's average HAZ value across survey years. By the standardized measure, Guatemala no longer has the highest FE, with six countries exceeding it: Zambia, Armenia, the Kyrgyz Republic, Bolivia, Peru, and Gabon.

Another way to examine how Guatemala fits into this model is by using the DFFITS statistic, which represents the "change in fit" of a regression line between including and excluding an observation. Dividing by the standardized deviation of the fit then standardizes this measure (Belsley, Kuh, and Welsch). DFFITS therefore aggregates the effect of both the residual and an observation's leverage, which is the degree to which that observation affects a model's outcome. Guatemala exceeds the DFFITS cutoff for the survey conducted in 1987, though not for the other two years. Eight observations have a higher DFFITS statistic (results displayed in Table 7 below).

The high values of the fixed effect and DFFITS statistic for Guatemala clearly indicate that this cross-country model cannot adequately explain the high prevalence of child stunting in Guatemala, and a more specific examination of the determinants of child malnutrition within Guatemala and the pathways through which maternal education impacts child stunting is required. For this, I will now turn to my Guatemala-specific study.

V.2. Guatemala-Specific Study

The Guatemala-specific regression results are displayed in Table 8 below. In the first model, the binary malnutrition status variable is regressed on the three dummy variables representing education attainment. Unsurprisingly, the pure education impacts are very large and significant, with the partial elasticities of primary, secondary, and tertiary education attainment at -25.3%, -88.4%, and -125.3%, respectively. These elasticities represent the percent change in probability that a child will be malnourished compared to the baseline (a woman with no education attainment). When including the geographic binary variables in Model 2 to account for region-specific variation, these effects remain significant at the 1% level but the elasticities decrease slightly.

In Model 3, I include indicators of household wealth and household characteristics to determine the effect of maternal education after controlling for socioeconomic status. In this model the partial elasticity of primary education falls to -7.5%, secondary education falls to -23.5%, and tertiary education decreases to -31.8%. This indicates that the large effect of primary education attainment found in Models 1 and 2 capture the effect of poverty on malnutrition, as the effect of primary education attainment is no longer economically significant in Model 3. It is important to note, however, that these socioeconomic indices may not fully capture each household's level of wealth. The partial elasticities of *HHWEALTH* and *HHCHAR* indices are -5.6% and -2.5%, respectively, a smaller effect than expected. Father's education attainment, then, captures the majority of the household wealth effect in this model, with paternal tertiary schooling attainment statistically significant with a partial elasticity of -15.8%.

Model 4 includes the index for health knowledge, as well as maternal literacy, Spanish language ability, and practice of correct breastfeeding practices. Including these variables also causes the partial elasticities of the maternal education variables to decrease, with primary education attainment again falling to an economically insignificant level (with a partial elascitity of -9.25%). Maternal literacy has a particularly significant effect, with a partial elasticity of -21.6%. These results suggest that much of the effect that schooling attainment has on child malnutrition can be explained by maternal literacy and knowledge of Spanish, which allow women to improve their health knowledge and enhances women's ability to take advantage of health services for the benefit of their families.

Surprisingly, though, the variable that represents correct duration of breastfeeding without supplemental food (six months) is positively associated with malnutrition. This result is both statistically and economically significant, although breastfeeding is widely recognized to improve child health, both directly through the infant's nutrition and by reducing a woman's fertility. However, previous studies have shown that the demographic that is more likely to breastfeed may also be at higher risk for malnutrition. Altiye, et al (2002) conducted an extensive study of breastfeeding patterns in peri-urban Guatemala City, and concluded that the most significant determinants of exclusive breastfeeding are the mother not working outside the home and Mayan heritage, while children born in the home were more likely to begin breastfeeding sooner than those born in clinics and hospitals. Women more likely to breastfeed correctly, then, may be more likely to utilize traditional rather than modern health care practices, meaning their children would be at a higher risk of stunting. In this sample, breastfeeding is negatively associated with wealth, which reflects Altiye, et. al's finding that women who breastfeed are less likely to work outside the home. Table 9 shows the correlation matrix for correct breastfeeding (*CORRECTBRSTFEED*) and the economic indicators, which demonstrates that mothers who breastfeed correctly are more likely to have lower values in the economic indices and lower paternal secondary and tertiary school attainment. Regressing *CORRECTBRSTFEED* on the economic indicators further demonstrates this relationship (Table 10). The *CORRECTBRSTFEED* variable may therefore also reflect residual wealth effects and attitudes towards health care that are unobserved in the model.

The results from the full model (Model 5, found in Table 8) present a clearer picture of how well these two pathways (household wealth and health knowledge) explain the impact of maternal education on child malnutrition. Socioeconomic factors seem to best explain this relationship, with father's secondary and tertiary education attainment, as a proxy for income, having the largest effect on the likelihood of child malnutrition. I also include indigenous status in this model, and find that the children of indigenous women are more likely to be stunted after controlling for factors such as socioeconomic status and language ability. This may be because indigenous women are more likely to follow traditional beliefs that prevent utilization or practice of modern medicine and nutritional advice. Indigenous families may also face systemic discrimination, as they may be more likely to reside in areas with limited access to health centers and lower-quality infrastructure.

The maternal education variables remain statistically significant in the full model, though the partial elasticity of primary education has fallen to an economically insignificant level of -4.6%. This suggests that the impact of primary education attainment can be almost entirely explained by socioeconomic factors, health knowledge (either learned directly in school or enhanced by literacy/numeracy skills), literacy, and Spanish ability. Maternal secondary and tertiary school attainment remain significant with partial elasticities of -31.2% and -46.9%, meaning that mothers with secondary education are 31.2% less likely than mothers with no education attainment to have a chronically malnourished child. This indicates that education impacts child malnutrition through factors excluded from this model, such as a greater willingness to utilize modern health care, higher status of women in the household, or unobserved income effects.

VI. Discussion and Conclusion

VI.1 Comparison of Cross-Country Results

In the previous section I presented the results of my cross-country analysis and discussed potential reasons for the lack of significant results. Here I compare my results with the results obtained by Smith and Haddad (2001) in their cross-country analysis of child malnutrition. Table 10 displays this comparison.

There are a few differences between the Smith and Haddad study and my study. First of all, Smith and Haddad use prevalence of underweight status, measured as the percent of the population with a weight-for-age z-score below -2, as their dependent variable. They also use female secondary school enrollment rates (FEMSED) rather than average years of female schooling attainment as the measure of female education. Finally, they include a measure of democracy (DEMOC) but do not include the Gini coefficient in their model. As shown in Table 10, Smith and Haddad obtain more significant results than I do, with water availability, with water availability, food supply per capita, life expectancy ratio, and democracy statistically significant. FEMSED is also significant at the 1% level. This could be because Smith and Haddad use a dataset with more observations: 179 observations from 63 countries, compared to my 130 observations from 53 countries.

The choice of dependent variables may also explain the discrepancies in statistical significance between the two models. It is possible that weight-for-age, which represents the aggregated effects of chronic malnutrition (low height-for-age) and acute malnutrition (low weight-for-height), can be better explained by the variables in this model than prevalence of stunting. For instance, it makes sense that per capita food availability has a larger effect on the prevalence of underweight, which directly reflects immediate calorie deficiencies, than on the prevalence of stunting. Stunting, as a measure of the long-term health of the child, may also be affected by more unobserved factors than underweight, such as cultural feeding practices, access to health services, and local availability of nutrient-rich foods.

VI.2 Limitations of this Study

My analysis of maternal education's effect on child health required the use of imperfect indicators from various data sources. Measurement error is of particular concern in both components of this study. In general, measurements of household characteristics in developing countries are notoriously unreliable. In the cross-analysis, estimations of indicators such as access to safe water require much extrapolation and are affected by regional variation (such as local perceptions of sanitation, in the safe water example). In the Guatemala-specific study, I created indices to measure household wealth in the absence of a direct measure of income. However, while these indices serve as general measures of economic status, unobserved wealth effects certainly remain in the model. Additionally, health knowledge is a nebulous concept that cannot be fully and directly measured. While my health knowledge index serves as a crude indicator, measurement error will surely bias the estimates to some degree. Another unobserved factor in my model is access to health care. The DHS and ENSMI surveys do not include information on proximity to health facilities, and the regional dummy variables reflect geographic areas that are too large to fully account for differences in access.

As previously mentioned, endogeneity will also bias the results of this study. Endogeneity is partially controlled for in the cross-country study with the FE model, though some of the regressors may be correlated with the time-variant error. For instance, countries with higher rates of malnutrition may also receive more international aid for improvements in health infrastructure. In the Guatemala-specific study, health knowledge is probably endogenous (correlated with the child's unobserved health endowment), so the impact of health knowledge on child health may be underestimated. My analysis also treats education attainment as exogenous, though this may not necessarily be the case. Education attainment, particularly beyond primary school, is probably highly correlated with the mother's cognitive ability and socioeconomic background, which could independently affect child health status. Because of this endogeneity, the effect of education attainment on child stunting may be overestimated. While I could, in theory, use the Instrumental Variables method to test and control for endogeneity, a lack of plausible instruments for health knowledge and education prevents this approach.

VI.2. Policy Suggestions and Conclusion

The purpose of this study was to examine the reasons for Guatemala's high stunting rate compared to other countries and determine the impact of maternal education on long-term child health. Despite the limitations of my study highlighted above, the results clearly highlight the importance of maternal education, specifically secondary school attainment, in reducing child stunting in Guatemala. Two general conclusions can be drawn from the cross-country analysis: the importance of maternal education as a determinant of child stunting worldwide, and that the model estimated using the 53-country sample cannot adequately explain the high levels of stunting within Guatemala. However, because female schooling attainment is included in the cross-country study, there must be unobserved influences that are excluded from my cross-country model that contribute to Guatemala's stunting rates. These factors could include quality of the education system, graduation rates from secondary institutions, or level of government investment in public services such as health infrastructure. Guatemala's sizable indigenous population could also partially explain its high stunting rates, perhaps through systemic discrimination or traditional attitudes towards health care.

The household-level ENSMI data provides the opportunity to examine more thoroughly how maternal education attainment affects malnutrition in Guatemala. This analysis reveals that the effect of primary education can be almost fully explained by economic factors and literacy, while maternal secondary and tertiary education attainment remains both statistically and economically significant even after these controls; indeed, these indicators have the highest partial elasticities of all the variables in the full model at -31% and -47%, respectively. These results indicate the particular importance of secondary school attainment, because from a policy perspective, expansion of tertiary education opportunities is more difficult to enact and will affect a smaller percentage of the population.

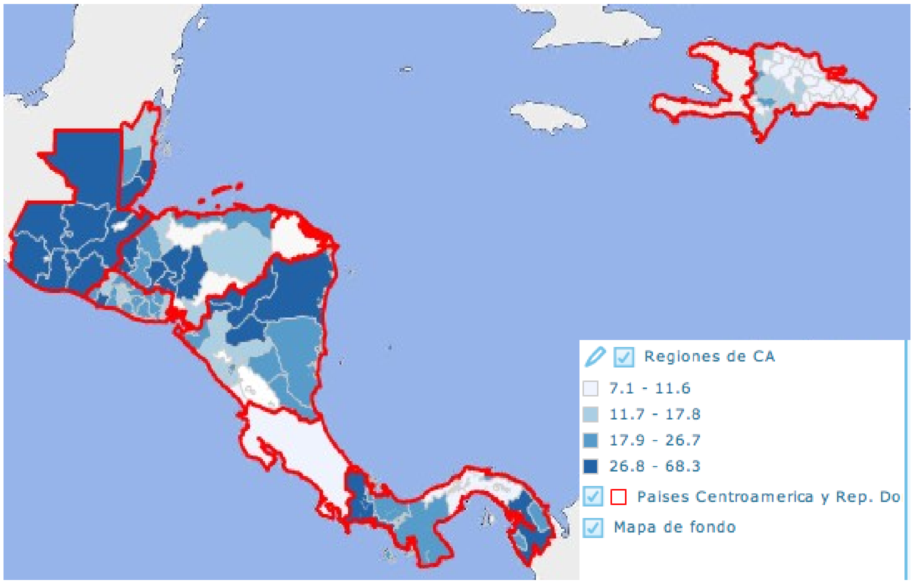
While my study cannot fully explain the specific mechanisms through which maternal education affects child health, it is clear that female education is a crucial component of reducing chronic malnutrition in Guatemala. Education attainment enables women to better secure the long-term health of their children by increasing their income, improving their health knowledge, and perhaps making them more likely to utilize health services. Maternal secondary school attainment, as recorded by the ENSMI surveys, has increased from 6.7% in 1987 to 25% in the 2008/9 survey. While this is a significant improvement, dramatic disparities remain between Guatemala and the rest of the region: Female secondary school enrollment rates in Guatemala have consistently trailed behind those in the rest of Latin America by about 40% in the past ten years (Figure 2). Low rates of female education attainment reflect a larger trend of persistent underinvestment in public services: indeed, Guatemala has one of the lowest tax rates in the world at 10% of GDP, which constrains the government's ability to provide its population with sufficient health and education infrastructure.

The Guatemalan government's current approach to improve chronic malnutrition, is outlined in the "Strategic Plan to Reduce Chronic Malnutrition," co-published by the Secretariat of Food Security and Nutrition, the same agency that carried out the ENSMI surveys. This document outlines the three direct and three livelihood components, which are predicted to reduce stunting by 24% by 2016. The direct components are basic health services such as family planning and immunizations, nutrition training and education, and maternal lactation and complementary feeding (such as distribution of vitamin supplements to breastfeeding women and children between 6 and 39 months). The livelihood components include expansion of safe water and basic sanitation services, improvements in household income through strengthening markets, and community organizing.

While this plan is theoretically sound, my research suggests that reducing chronic Malnutrition (specifically measured by stunting) requires a more fundamental improvement in public services. Combating chronic malnutrition requires providing women with the tools to care for the long-term health of their children, including non-tangible assets such as literacy, numeracy, and basic health knowledge, in addition to tangible resources such as sufficient income, sanitation, and health services. While nutrition trainings are an important tool, they do not provide the same effect on literacy and numeracy skills as schooling attainment, and will not affect household income. Empirical evidence strongly suggests that a long-term strategy to reduce chronic malnutrition must include the goal of raising female graduation rates from secondary education.

Appendix

Figure 1: Stunting Prevalence by Region in Guatemala and Neighboring Countries



Source: INCAP 2011

Table 1: Countries and Survey Years, Cross-Country Study

1.	Armenia	2000
2.	Armenia	2005
3.	Bangladesh	1996
4.	Bangladesh	1999
5.	Bangladesh	2004
6.	Benin	1996
7.	Benin	2001
8.	Bolivia	1989
9.	Bolivia	1993
10.	Bolivia	1998
11.	Bolivia	2003
12.	Brazil	1986
13.	Brazil	1996
14.	Burkina Faso	1992
15.	Burkina Faso	1998
16.	Burkina Faso	2003
17.	Burundi	1987
18.	CAR	1994
19.	Cambodia	2000
20.	Cambodia	2005
21.	Cameroon	1991
22.	Cameroon	1998
23.	Cameroon	2004
24.	Chad	1996
25.	Chad	2004
26.	Colombia	1986
27.	Colombia	1995
28.	Colombia	2000
29.	Colombia	2004
30.	Comoros	1996
31.	Cote d'Ivoire	1994
32.	Cote d'Ivoire	1998
33.	Dominican Rep.	1990
34.	Dominican Rep.	1991
35.	Dominican Rep.	1996
36.	Dominican Rep.	2002
37.	Egypt	1988
38.	Egypt	1992
39.	Egypt	1995
40.	Egypt	2000
41.	Egypt	2003
42.	Egypt	2005
43.	Ethiopia	1992
44.	Ethiopia	1997
45.	Gabon	2000
46.	Ghana	1988
47.	Ghana	1993
48.	Ghana	1998
49.	Ghana	2003
50.	Guatemala	1987
51.	Guatemala	1995
52.	Guatemala	1998
53.	Guinea	1999
54.	Guinea	2005
55.	Haiti	1994
56.	Haiti	2000
57.	Haiti	2005
58.	India	1992
59.	India	1998
60.	India	2005
61.	Kazakhstan	1995
62.	Kazakhstan	1999
63.	Kenya	1993
64.	Kenya	1998
65.	Kenya	2003
66.	Kyrgyz Republic	1997
67.	Madagascar	1992
68.	Madagascar	1997
69.	Madagascar	2003
70.	Malawi	1992
71.	Malawi	2000
72.	Malawi	2004
73.	Mali	1987
74.	Mali	1995
75.	Mali	2001
76.	Morocco	1987
77.	Morocco	1992
78.	Morocco	2003
79.	Mozambique	1997
80.	Mozambique	2003
81.	Namibia	1992
82.	Namibia	2000
83.	Nepal	1996
84.	Nepal	2001
85.	Nicaragua	1997
86.	Nicaragua	2001
87.	Niger	1992
88.	Niger	1998
89.	Niger	2006
90.	Nigeria	1990
91.	Nigeria	1999
92.	Nigeria	2003
93.	Pakistan	1990
94.	Paraguay	1990
95.	Peru	1991
96.	Peru	1996
97.	Peru	2000
98.	Peru	2005
99.	Rwanda	1992
100.	Rwanda	2000
101.	Rwanda	2005
102.	Senegal	1986
103.	Senegal	1992
104.	Senegal	2005
105.	Sri Lanka	1987
106.	Tanzania	1991
107.	Tanzania	1996
108.	Tanzania	1999
109.	Tanzania	2004
110.	Thailand	1987
111.	Togo	1988
112.	Togo	1998
113.	Trinidad & Tob.	1987
114.	Tunisia	1988
115.	Turkey	1993
116.	Turkey	1998
117.	Turkey	2003
118.	Uganda	1988
119.	Uganda	1995
120.	Uganda	2000
121.	Uganda	2006
122.	Uzbekistan	1996
123.	Yemen	1991
124.	Zambia	1992
125.	Zambia	1996
126.	Zambia	2001
127.	Zimbabwe	1988
128.	Zimbabwe	1994
129.	Zimbabwe	1999
130.	Zimbabwe	2005

Table 2: Sources and Summary Statistics, Cross-Country Model

Variable Name							
	Percent of the population with access to water						

Table 3: Sources and Sample Sizes, Guatemala-Specific Study

Table 4: Variable Frequencies, Guatemala-Specific Study

Variable Name	Definition		Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
RURAL	rural/urban	Urban	590	28.02	1527	25.18	798	26.34	1,137	26.52	2,926	39.07
		Rural	1516	71.98	4538	74.82	2232	73.66	3,151	73.48	4,563	60.93
		Total	2106	100	6065	100	3030	100	4,288	100	7,489	100
GEOG	region of country	Guatemala	406	19.28	489	8.06	192	6.34	432	10.07	703	9.39
		Central	238	11.3	704	11.61	232	7.66	583	13.6	772	10.31
		Southwest	544	25.83	688	11.34	318	10.5	331	7.72	1,190	15.89
		Northwest	315	14.96	528	8.71	229	7.56	298	7	907	12.11
		North	179	8.5	993	16.37	372	12.28	486	11.33	908	12.12
		Northeast	209	9.92	1646	27.14	612	20.2	1,056	24.63	1,858	24.81
		Northwest	215	10.21	1017	16.77	425	14.03	732	17.07	803	10.72
		Peten	----	----	----	----	650	21.45	370	8.63	348	4.65
		Total	2106	100	6065	100	3030	100	4,288	100	7,489	100
ETHN	ethnicity	Indigenous	901	42.78	2921	48.16	1780	58.75	2,292	53.46	3,996	54.41
		Ladino	1205	57.22	3144	51.84	1250	41.21	1,995	46.54	3,348	45.59
		Total	2106	100			3030	100	4,287	100	7,344	100
LANG	language spoken in	Indigenous language	742	35.23	2223	36.65	980	32.34	1,642	38.29	5,479	73.16
		Spanish	1363	64.77	3842	63.35	2050	67.66	2,646	61.71	2,010	26.84
		Total	2106	100	6065	100	3030	100	4,288	100	7,489	100
SPN	Understands	Yes	1556	79.92	5044	16.83	503	16.6	938	57.3	6,723	89.77
		No	391	20.08	1021	83.17	2527	83.4	699	42.7	766	10.23
		Total	1947	100	6065	100	3030	100	1,637	100	7,489	100
MEDUC	mother's education	No education	944	48.48	2567	42.32	1141	37.66	123	4.45	207	3.65
		Primary	855	43.91	2895	47.37	1541	50.86	2,107	76.26	3,810	67.27
		Secondary	130	6.68	532	8.77	315	10.4	488	17.66	1,415	24.98
		Higher	18	0.92	71	1.17	33	1.09	45	1.63	232	4.1
		Total	1947	100	6065	100	3030	100	2,763	100	5,664	100

MLIT	mother's literacy	Reads	949	49	3223	53.26	1754	58.06	1999	56.04	2,156	28.79
		Cannot read	998	51.26	2828	46.74	1267	41.94	1,568	43.96	5,333	71.21
		Total	1947	100	6051	100	3021	100	3,567	100	7,489	100
			949	100	5530	100	3019	100	2,693	100	1,001	100
FEDUC	Father's educ	None	701	37.39	1718	29.7	812	27.68	84	2.82	162	2.85
		Primary	929	49.55	3279	56.69	1650	56.26	2,221	74.61	3,752	66.02
		Secondary	205	10.93	647	11.19	406	13.84	585	19.65	1,481	26.06
		Higher	40	2.13	140	2.42	65	2.22	87	2.92	288	5.07
		Total			5784	100	2933	100	2,977	100	5,683	100
WSOURCE	water source	Piped, public	766	36.37	2,747	45.34	1,547	51.07	1,888	44.06	3,085	41.19
		Public tap	37	1.76	405	6.68	154	5.08	160	3.73	200	2.67
		Other source, piped	120	5.7	759	12.53	105	3.47	555	12.95	1,329	17.75
		Well	261	12.39	1,052	17.36	598	19.74	120	2.8	947	12.65
		River or stream	441	20.94	819	13.52	361	11.92	681	15.89	589	7.86
		Water tank	396	18.8	22	0.36	53	1.75	445	10.39	93	1.24
		Rainwater	7	0.33	46	0.76	12	0.4	69	1.61	66	0.88
		Bottled water	10	0.47	179	2.95	189	6.24	16	0.37	1,144	15.28
		Other	68	3.23	30	0.5	10	0.33	301	7.02	36	0.48
		Total	2106	100	6059	100	3,029	100	50	1.17	7,489	100
TOILET	Type of toilet	No toilet	780	37.04	1,332	22.01	710	23.51	1,676	39.11	1,002	13.38
		Flush toilet, or	353	16.76	1,043	17.23	756	25.03	222	5.18	3,020	40.33
		Latrine or pit toilet	918	43.59	3673	60.68	1,548	51.26	2,362	55.12	3,406	45.48
		Other	55	2.61	5	0.08	6	0.2	25	0.58	61	0.81
		Total	2106	100	6,053	100	3,020	100	4,285	100	7,489	100

Table 5: RE and FE Regression Results, Cross-Country Analysis. Dependent Variable is HAZ

VARIABLES		
	(0.0312)	(0.0345)
	(0.00227)	(0.00281)
	(0.493)	(0.778)
	(0.000466)	(0.000857)
	(6.624)	(6.606)
	(0.0555)	(0.0572)
	(3.639)	
	(3.133)	(3.539)
	(8.942)	
	(2.830)	(2.940)
	(9.441)	(10.24)

Table 6: Correlation matrix

	haz	watraval	foodaval	yr_sch	gdp	leratio	gini
haz	1.0000						
watraval	-0.3666	1.0000					
foodaval	-0.5066	0.4005	1.0000				
yr_sch	-0.5514	0.4216	0.1954	1.0000			
gdp	-0.6318	0.3832	0.5589	0.4581	1.0000		
leratio	-0.1943	0.0637	-0.0523	0.2009	0.0654	1.0000	
gini	-0.1097	0.0430	0.0925	0.0736	0.1196	-0.0331	1.0000

Table 7: DFFITS Exceeding Cutoff, FE

1. Brazil	-3.030671
2. Turkey	-2.711756
3. Zambia	-2.400553
4. Zimbabwe	-2.023194
5. Namibia	-2.008731
6. Cameroon	-1.878255
7. Ethiopia	-1.863807
8. Mali	-1.685433
9. Armenia	-1.601086
10. Guinea	-1.555276

111.	Nigeria	1.410972
112.	**Guatemala (1987)**	**1.529945**
113.	Guinea	1.555276
114.	Armenia	1.601086
115.	Zambia	1.73795
116.	Ethiopia	1.863807
117.	Namibia	2.008731
118.	Zimbabwe	2.285202
119.	Brazil	3.030671

Table 8: Probit Regression Results (Partial Elasticities), Guatemala-Specific Study. Dependent Variable is MALN

	(0.0116)	(0.0119)	(0.00651)	(0.0136)	(0.0142)
	(0.0212)	(0.0222)	(0.0117)	(0.0255)	(0.0278)
	(0.0613)	(0.0625)	(0.0263)	(0.0635)	(0.0696)
			(0.00860)		(0.0172)
			(0.0129)		(0.0257)
			(0.0263)		(0.0542)
			(0.00310)		(0.00619)
			(0.00394)		(0.00780)
				(0.0163)	(0.0176)
				(0.0155)	(0.0160)
				(0.0293)	(0.0299)
				(0.0136)	(0.0138)
					(0.0139)
		(0.0136)	(0.00778)	(0.0139)	(0.0153)
		(0.0301)	(0.0157)	(0.0304)	(0.0315)
		(0.0275)	(0.0135)	(0.0279)	(0.0287)
		(0.0270)	(0.0140)	(0.0274)	(0.0280)
		(0.0282)	(0.0144)	(0.0287)	(0.0294)
		(0.0271)	(0.0136)	(0.0274)	(0.0285)
		(0.0250)	(0.0125)	(0.0253)	(0.0262)
		(0.0267)	(0.0126)	(0.0270)	(0.0279)

Table 9: Correlations, Correct Breastfeeding and Socioeconomic Indicators

	CORREC~D	HHCHAR	HHWEALTH	FPRIM	FSEC	FTERT
CORRECTBRS~D	1.0000					
HHCHAR	-0.1887	1.0000				
HHWEALTH	-0.2025	0.5848	1.0000			
FPRIM	0.0338	-0.1190	-0.0835	1.0000		
FSEC	-0.1482	0.3494	0.3562	-0.4464	1.0000	
FTERT	-0.0760	0.2079	0.2137	-0.1757	-0.0723	1.0000

Table 10: Probit regression results, dependent variable is *CORRECTBRSTFEED*

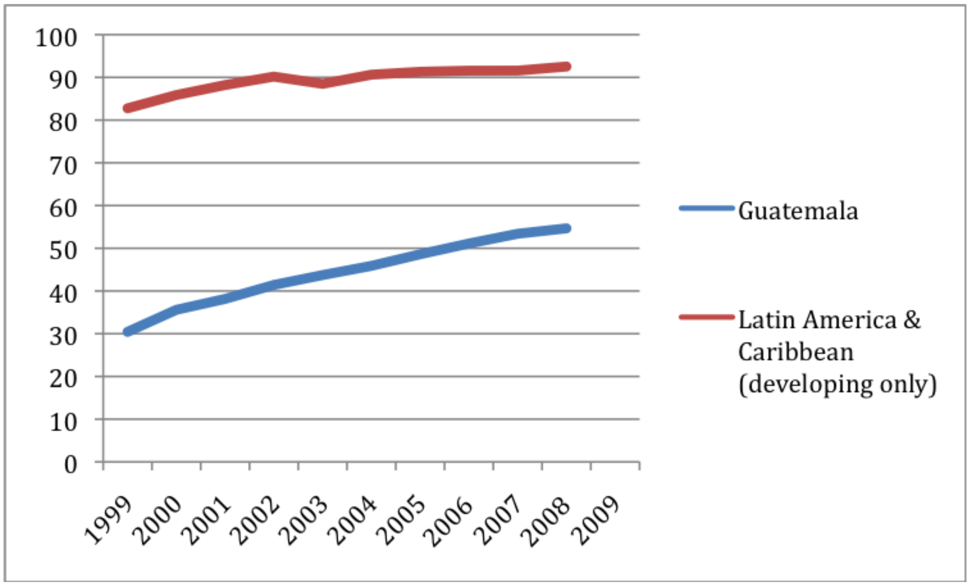
	(0.00732)
	(0.00940)
	(0.0164)
	(0.0236)
	(0.0444)
Observations	5,056

Table 10: Comparison of Cross-Country Results (Dependent Variable is *HAZ*) with Smith-Haddad Study (Dependent Variable is Prevalence of Underweight).

	Taylor FE Results	Smith-Haddad FE Results
Variables		
watraval (SAFEW)	-0.0122	-0.069*
	(0.0345)	(1.7)
foodaval (DES)	-0.00182	-0.0077**
	(0.00281)	(2.21)
yr_sch	-3.505***	
	(0.778)	
femsed		-0.177***
		(2.78)
leratio	-0.361	-111**
	(6.606)	(2.6)
gini	-0.0333	
	(0.0572)	
democ		-0.779*
		(1.68)
gdp	-0.00127	1.20E-04

	(0.000857)	(.137)
Observations	130	179
Number of cid	53	63

Figure 2: Gross Secondary School Enrollment Rates, Female



Source: World Development Indicators (2010)

References

Barro, Robert, and Jong-Wha Lee. *Barro-Lee Educational Attainment Dataset*. 2010. Web. <http://www.barrolee.com/>.

Bicego, George, and J. T. Boerma. "Maternal Education and Child Survival: A Comparative Study of Survey Data from 17 Countries." *Social Science Medicine* 36.9 (1993): 1207-227. Print.

Bhagowalia, Priya. "The Distribution of Child Nutritional Status Across Countries and Over Time." Diss. Purdue University, 2008.

Block, Steven, and Patrick Webb. "Nutrition Information and Formal Schooling as Inputs to Child Nutrition." *Economic Development and Cultural Change* 52.4 (2004): 801-20.

Dearden, Kirk, Mekip Altaye, Irma De Maza, Maritza De Oliva, Maryanne Stone-Jiminez, Ardythe Morrow, and Burton Burkhalter. "Determinants of Optimal Breastfeeding in Per-urban Guatemala City." *Public Health* 12.3 (2002): 185-92. Print.

Defo, Barthelemy K. "Effects of Socioeconomic Disadvantage and Women's Status on Women's Health in Cameroon." *Social Science Medicine* 44.7 (1997): 1023-042.

Demographic and Health Surveys. Guatemala: 1987, 1995, 1998-9. <http://www.measuredhs.com/.>

Doan, Rebecca, and Leila Bisharat. "Female Autonomy and Child Nutritional Status: The Extended-Family Residential Unit in Amman, Jordan." *Social Science Medicine* 31.7 (1990): 783-89. Print.

Encuesta Nacional de Salud Materna-Infantil. 2002, 2008-9. Center for Disease Control. Atlanta, GA. Downloaded from CD.

FAOSTAT. Food and Agirculture Organization, 2009. Web. <http://faostat.fao.org/site/357/default.aspx>.

Frost, MB, RW Forste, and DW Haas. "Maternal Education and Child Nutritional Status in Bolivia: Finding the Links." *Social Science and Medicine* 60, no. 2 (Jan 2005): 395-407

Garcia, Oliviero Rodas. Personal Interview, May 2008.

Glewwe, Paul. "Why Does Mother's Schooling Raise Child Health in Developing Countries? Evidence from Morocco." *The Journal of Human Resources* 34.1 (1999): 124-59.

Glewwe, Paul, Elizabeth King, and Hanan Jacoby. "Early Childhood Nutrition and Academic Achievement: a Longitudinal Analysis." *Journal of Public Economics* 81.3 (2001): 345-68.

Gragnolati, M. "Children's Growth and Poverty in Rural Guatemala." *World Bank Human Development Sector Unit,* Jan 1999

Grandin, Greg. "Chronicles of a Guatemalan Genocide Foretold: Violence, Trauma, and the Limits of Historical Inquiry." *Nepantla: Views from South* 1.2 (2000): 391-412.

"Guatemala | Data." *Data | The World Bank*. Web. 19 Apr. 2011. <http://data.worldbank.org/country/guatemala>.

"Guatemala | International Development Exchange." *Home | International Development Exchange*. Web. 19 Apr. 2011. <http://www.idex.org/what-we-do/where-guatemala.php>.

Global Water Supply and Sanitation Assessment. 2000. Web. <http://www.who.int/docstore/water_sanitation_health/Globassessment/GlobalTOC.htm>.

Heaton, TB, R Forste, JP Hoffman, and D Flake. “Cross-National Variation in Family Influences on Child Health.” *Social Science and Medicine* 60, no. 1 (Jan 2005): 97-108

"Historia De La Alimentación Escolar En Guatemala." *Nutrinet.org*. 26 May 2009. Web. 2 Mar. 2011. <http://guatemala.nutrinet.org/areas-tematicas/alimentacion-escolar/casos-exitosos/201-historia-de-la-alimentacion-escolar-en-guatemala>.

Hobcraft, John. "Women's Education, Child Welfare, and Child Survival: a Review of the Evidence." *Health Transition Review* 3.2 (1993): 159-73. Print.

Immink, M D, and E Payongayong. “Risk Analysis of Poor Health and Growth Failure of Children in the Central Highlands of Guatemala.” *Social Science and Medicine* 48, no. 8 (Apr 1999): 1997-1009

Larrea, C, and I Kawachi. “Does Economic Inequality Affect Child Malnutrition? The Case of Ecuador.” *Social Science and Medicine* 60, no.1 (Jan 2005): 165-78

Marini, Alessandra, and Michele Gragnolati. "Malnutrition and Poverty in Guatemala." World Bank Working Paper No. 2967 (2003).

Milman, A, E Frongillo, M de Onis, and J Hwang. “Differential Improvement Among Countries in Child Stunting is Associated with Long-Term…” *Journal of Nutrition* 135 (Jan 2005):1415-1422

Morales, R, AM Aguilar, and A Calzadilla. “Geography and Culture Matter for Malnutrition in Bolivia.” *Economics and Human Biology* 2, no. 3(Dec 2004): 373-89

Programa Para La Reducción De La Desnutrición Crónica, 2006-2016. Rep. Guatemala City: SESAN-Gobierno De Guatemala.

Sahn, D. and D. Stifel. “Robust Comparisons of Malnutrition in Developing Countres.” *Amerian Journal of Agricultural Economics* 84, no. 3 (Aug 2002): 716-735

Seerabutra, P, N Solomons, M Aliyu, and P Jolly. “Sociodemographic and Environmental Predictors of Childhood Stunting in Rural…” *Nutrition Research* 26 (Jan 2006): 65-70

Shah SM, Selwyn BJ, Luby S, Merchant A, Bano R. Prevalence and correlates of stunting among children in Rural Pakistan. Pediatr Int 2003; 45:49-53

Smith, L. and L. Haddad. *Explaining Child Malnutrition in Developing Countries: A Cross-Country Analysis.* International Food Policy Institute 2000

UNU-WIDER. 1995-2011. Web. <http://www.wider.unu.edu/research/Database/en_GB/database/>.

Valdivia, M. “Poverty, Health Infrastructure and the Nutrition of Peruvian Children.” *Economics and Human Biology* 2, no. 3 (Dec 2004): 489-510

Van De Poel, Ellan, A.R. Hosseinpoor, C. Jehu-Appiah, J. Ve, and N Speybroeck. "Malnutrition and the Disproportional Burden on the Poor: the Case of Ghana." *International Journal for Equity in Health* 6 no. 21 (2007)

World Development Indicators. The World Bank, 2010. Web.

<http://data.worldbank.org/indicator>.