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Association between maternal deworming and stunting in the offspring in Guatemala, Central America

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Degree to be awarded: Master of Public Health

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An abstract of a thesis submitted to the faculty of the Rollins School of Public Health of Emory University in partial fulfillment of the requirements for the degree of Master of Public Health in Applied Epidemiology 2019

Abstract

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Soil- transmitted helminth (STH) infections are among the most common infections in humans, particularly in low-income, developing countries where there is poor sanitation infrastructure. A vast majority of children and adults in Guatemala, Central America are heavily infected with parasites leaving them sick and undernourished. Anthelmintic medications are recommended to populations at risk, to include pregnant women in their second and third trimesters. Women who are undernourished are likely to have an undernourished, stunted child. While stunting results in short stature, it also contributes to cognitive impairment and chronic disease later in life. The objective of this study was to examine whether maternal use of anthelmintics (deworming) for STH infections during pregnancy is associated with stunting in children in Guatemala, Central America. Survey data from the 2014-2015 Demographic and Health Surveys (DHS) Program in Guatemala was used to assess the relationship between maternal deworming and stunting in the offspring. Multivariate logistic analysis, accounting for the complex survey design, was used to obtain the odds ratios with 95 % confidence intervals; interaction was only identified by place of residence (rural or urban status). There was no significant association between child stunting and maternal deworming in urban areas (OR, 0.67; 95% CI, 0.28-1.57), but there was a significant association between child stunting and maternal deworming in rural areas (OR, 2.00; 95% CI, 1.01-3.97). Children of the mothers who received anthelmintics in rural areas were more two times more likely to be stunted than the children of the women who did not receive anthelmintics during pregnancy. Despite these findings, there are known benefits of deworming during pregnancy. In addition, it is unknown whether the results from families living in rural area are causal or if there may be other factors that might explain the association, we observed in this study. Further study is warranted to determine whether any potential risk in increased stunting outweighs the benefits of interrupting STH transmission.

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This thesis is dedicated in memory of my mother, Gail, who I lost during my time at Rollins. As a retired educator, she could not have been prouder of me for becoming a student at Emory University. She called herself an "Emory Mom" and I have finally made her just that. This thesis is also dedicated to my partner Dr. Vincent Krogmann, he is my every day gift. His tireless support, strength, and love gave me a place to lean during the times that I thought this MPH was unobtainable.

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LIST OF ABBREVIATIONS AND ACRONYMS

CI	Confidence Interval
DHS	Demographic Household Survey
HAZ	Height for Age Z-score
IUGR	Intrauterine Growth Restriction
LBW	Low Birth Weight
NTD	Neglected Tropical Disease
OR	Odds Ratio
RCT	Randomized Controlled Trials
STH	Soil-Transmitted Helminths
VLBW	Very Low Birth Weight
WHO	World Health Organization

Chapter I: Review of the Literature

Soil- transmitted helminth (STH) infections are among the most common infections in humans, particularly in low-income, developing countries.[1] STH infections in humans include the roundworm (*Ascaris lumbricoides*), whipworms (*Trichuris trichiura*), and two species of hookworms (*Ancyclostoma duodenale, Necator americanis*); these infections affect more than 1 billion people worldwide with more than 4 billion people at risk.[1,2] These parasites are designated as Neglected Tropical Diseases (NTD's) because they persist among low-income populations in developing regions and cause a disproportionate burden due to the deleterious effect on worker productivity, child development, and the health of girls and women.[3] The transmission of STH is most prevalent in areas where there is poor sanitation, where fecal contamination in the soil is higher. NTD's are common in tropical areas and where people have little access to clean water or proper ways to dispose of human waste.[1] Women and children who live in unsanitary environments face the biggest threat of NTD transmission. These three STH's share a common lifecycle where infective larva are ingested and subsequently inhabit the intestinal wall where they reproduce, the eggs then shed in the feces, contaminating the environment once again in areas of poor sanitation.[1] Hookworm infection in particular will cause micro-bleeding at the sites of parasite attachment causing blood loss resulting in, or exacerbating existing, iron deficiencies.[1] Roundworm and whipworm infections can also result in intestinal blood loss and impair the absorption of nutrients, to include interfering with vitamin uptake. [1,4] In Guatemala, Central America, families often lack the proper means of basic sanitation. Often the toilet is a latrine that is non-flushing and uncovered, and merely a hole dug into the ground for elimination. Often families lack

access to clean water, making handwashing and washing food before consumption difficult; more than one quarter of the rural populations lacks access to clean sanitation facilities.[4] It is often that the floor substrate in houses are dirt, where parasite larva can thrive. A vast majority of children and adults in Guatemala are heavily infected with parasites, keeping them sick, underdeveloped, and undernourished. [4] STH infection results in anemia, vitamin deficiencies, malnutrition, vomiting and diarrhea, and intestinal blockage; if control of STH's is not achieved, long-term effects are impaired cognitive development leading to decreased educational and worker productivity, continued poverty, and stunted growth. [2,4]

Because those living in poverty are most vulnerable to STH infections, preventive chemotherapy of anthelmintic medications are recommended to populations at risk and those most vulnerable to the effects of STH's, to include pregnant women in their second and third trimesters. [5] Hookworms specifically are estimated to affect 44 million pregnancies globally each year, posing a threat to the mother and the fetus because these infections are associated with intestinal blood loss, protein and nutrient loss/malabsorption for erythropoiesis, iron deficient anemia, diarrhea, intestinal inflammation and obstruction, and low birthweight babies.[6] Pregnant women are especially vulnerable to the consequences of parasitic infection due to increased nutritional demands during pregnancy. [1] Maternal malnutrition can lead to decreased fetal growth and infant malnutrition and mortality.[6] While anthelmintic medications are efficacious in treating STH's and have minimal side effects, little has been known about the potential beneficial effects of these medications during pregnancy since their use was generally avoided due to absence of safety data.[6,7] Because of the heightened awareness

that STH infections impose a large economic and health burden on poor populations and because subsequent safety data was established for anthelmintics at recommended doses after the first trimester, anthelmintic treatment during the 2nd and 3rd trimesters of pregnancy became a part of the World Health Organization's (WHO) strategy in 1994 for pregnant women in developing countries.[5] The WHO recommends maternal deworming where the baseline prevalence of hookworm and whipworms is ≥20 % among pregnant women and where anemia is of severe public health concern (i.e. prevalence ≥40 % among pregnant women).[5] The recommended anthelmintic protocol is defined as a single dose of albendazole (400 mg) or mebendazole (500 mg) after the 1st trimester among pregnant women, even without previous diagnosis, living in these endemic areas.[5] It was anticipated that this recommendation would have beneficial results in reducing anemia, increasing birthweight, and reducing perinatal and infant mortality. Despite these recommendations, few endemic countries have incorporated routine maternal deworming.[8] Despite the few maternal deworming trials have been conducted, benefit of treatment for STH's during pregnancy needs further examination because in a trial setting, it is imperative to also provide iron and folate supplementation as part of the antenatal visit while the women are present and seeking care, which may override some knowledge of potential benefit of anthelmintic treatment.[4] However, since Guatemala has the highest rate of STH infections in Central America, there are periodic deworming campaigns every year for children, but not specifically as part of routine antenatal care.[8]

Over the last decade, the potential beneficial effects of deworming during pregnancy have been investigated in multiple meta-analyses. A meta-analysis performed in 2012 aimed to determine the effect of anthelmintic treatment in pregnancy on maternal,

newborn, and child health. This meta-analysis of four studies showed that few Randomized Control Trials (RCT's) collectively failed to show significant benefits on maternal anemia, low birthweight (LBW), or perinatal mortality of anthelmintic treatment groups.[1] The meta-analysis did, however, show a significant reduced risk of very low birthweight (VLBW). Two of the three trials that examined maternal anemia as the outcome, showed a benefit of anthelmintics in certain groups, for example, women with high worm burdens.[1] This same meta-analysis examined three observational studies with maternal anemia as the outcome, which showed a beneficial impact of anthelmintics on maternal anemia.[1] Despite the limitations in available data in this particular meta-analysis and the confounding factor that a majority of these trials included concomitant iron supplementation to the subjects, the mode of action of anthelmintics to function to reduce parasites that cause intestinal bleeding and deprive absorption of nutrients is known, however larger trials are needed to show significant benefit of anthelmintic treatment in pregnant women without potential confounding effects. [1,4] In a 2015 meta-analysis reviewing four trials, with two trials that were also included in the 2012 meta-analysis, the effects of anthelmintics during the 2nd and 3rd trimesters of pregnancy were reviewed with maternal anemia as the primary outcome and LBW, pre-term birth, and perinatal mortality as secondary outcomes.[6] In the four trials that reported the primary outcome of anemia after administration of an anthelmintic in the second trimester, there was no significant impact, however concomitant supplementation of iron in one of the trials did show a benefit on maternal anemia. There was no significant impact in the secondary outcomes of LBW, pre-term birth, or perinatal mortality. As with the 2012 meta-analysis, larger trials are needed in a broader range of settings to provide stronger

evidence of benefit for maternal deworming.[1,6] In a 2017 meta-analysis to assess the impact of deworming intervention on maternal and child health, twelve out of the fifty eight studies that were reviewed included pregnant women; the outcomes of interest in these twelve studies were perinatal mortality, maternal anemia, maternal hemoglobin, and birthweight.[9] While some of the studies in this meta-analysis showed benefits of deworming during pregnancy in regards to these outcomes, a variety of limitations continue to exist, including small sample sizes, confounding by concomitant vitamin and mineral supplementation, and loss to follow up.[9] While research suggests that deworming in general is beneficial; it is unclear if there is measurable benefit in pregnant women or the development of their offspring.

Stunting, or short stature for one's age, is a public health concern that plagues low-income, developing countries, and is evidence of chronic restriction of a child's growth. It is more thoroughly defined as having a height for age z-score (HAZ) that is more than two standard deviations (z-scores) below the WHO's Child Growth Standards median and results from a multitude of factors, to include health and nutrition of the mother during pregnancy.[10] Because stunting is multifactorial, it can be a difficult challenge to overcome especially in countries lacking both diagnostic and medical resources. Guatemala ranks among the highest in stunting rates with 50% of the population affected, despite years of programs designed to improve nutrition and maternal and child health.[4] The problem is more common among rural, indigenous people than in urban areas, but it is often difficult for the people of Guatemala to see stunting as a problem of malnutrition when it has been, and still can be, perceived as the ancestral norm defined by genetics and not by health and nutrition deficiencies.[4] The problem with stunting is not just one of

stature, but it has lasting effects throughout an affected individual's lifetime and society to include diminished cognitive and physical development, reduced productivity, and increased risk of metabolic disease. [2,10] The determinants that contribute to stunting can include inadequate infant and child feeding, infections and disease related to inadequate sanitation and water quality, and maternal health and nutrition. These determinants are often interrelated, with one factor leading to another; for example, inadequate sanitation can lead to ill health from diarrheal diseases and parasites, and parasites can lead to inadequate nutritional absorption, which can lead to anemia. Maternal nutritional health should include the periods before, during and after pregnancy as this influences a child's early growth and development; the effects of maternal malnutrition on the developing fetus can be numerous and severe.[10] Intrauterine growth restriction (IUGR), a condition where a baby's growth slows or ceases while in utero and a predictor for stunting, is more common among women who are malnourished and underweight at the beginning of pregnancy.[11] A global review of stunting in low to middle income countries identified intrauterine growth restriction and lack of sanitation as the main drivers of stunting, confirming that early intervention is needed because stunting is often irreversible after the first 2 years of life.[1, 11] Maternal malnutrition, which creates a less than optimal uterine environment, may induce permanent anatomical and functional changes in various tissues and organs of the fetus, subsequently leading to increased risk of metabolic, cardiovascular disease, and overall poor health outcomes [7]. A large prospective study of pregnant women living in Guatemala City found an increased incidence of IUGR in pregnant women with high intensity helminth infections; among the malnourished pregnant women with *Trichuris* and *Ascaris* infections, the rates of IUGR were 5 to 9

times higher than non-infected pregnant mothers.[1] The first 1000 days (from conception to age 2) is the term that refers to the critical period during which intervention is crucial to reduce adverse health outcomes for both the mother and child. However, others argue that it is the first 500 days (from conception to 6 months of age), the time when an infant is entirely dependent for its nutrition from the mother via the placenta and then ideally thru exclusive breastfeeding, that is the most critical. [4,11] Numerous interventions have been implemented in Guatemala to prevent stunting, but the country continues to fall behind in growth and malnutrition rates.

To intersect the effects of anthelmintic treatment in pregnant women in reducing STH's to improve maternal nutritional status to the outcome of stunting in their offspring, it is understood that STH infections can cause malnutrition and anemia in pregnant women, both of which can lead to IUGR. If IUGR is a predictor for stunting, the underlying causes of this condition and potential interventions for preventing it, need further examination. STH infections take nutrients away from pregnant women, which causes malnutrition, which can lead to anemia, vitamin and mineral loss, and finally to growth limitations in the fetus. While it is known that fetal malnutrition is a result of maternal malnutrition, whether it is food insecurity, poor nutritional choice, or infectious disease, all are important determinants of stunting. However, little or nothing is known about the intersection of maternal deworming against STH's as an effective intervention against stunting. The objective of this study is to examine whether maternal deworming for STH infections during pregnancy has an impact on stunting in children in Guatemala, Central America.

Chapter II: Journal Article

Introduction

Guatemala is in a malnutrition crisis that has been continuing for decades, a crisis that has left a majority of the population stunted, otherwise referred to as small stature (height) for age. [11] Stunting is caused by malnutrition and while there are multiple determinants for malnutrition, it can originate even before a child is born. Stunting typically develops in the first 1000 days of the child's life- from the time of conception through age two. [12] Despite numerous public health interventions targeting nutrition, Guatemala continues to have higher rates of stunting than its neighboring countries and has the third highest rates of stunting in the world.[11] Guatemala has had no reduction in malnutrition rates over the last decade, losing over US$300 million in gross domestic product (GDP) to vitamin and mineral deficiencies every year. This is particularly problematic when you consider that scaling up core micronutrient nutrition interventions would cost less than US$16 million per year.[11] While countries with more severe income inequalities have improved malnutrition rates, Guatemala continues to fall behind.[13] The country has stark divisions between its rich and poor communities. The populations that are largely affected with malnutrition and stunting are the indigenous communities, made up mostly by sharecropping farmers, who have twice the rates of stunting than those in non-indigenous communities.[11] Because the malnutrition crisis is so widespread, the affected populations themselves do not realize that stunting is a problem, but it contributes to lower cognitive development, lower education level, lower social economic status and productivity, and higher risk of chronic diseases later in life.[11,13]

The determinants of chronic malnutrition and stunting in Guatemala are attributable to many factors, but the greatest driver is poverty, which results in poor nutrition and health.[13] Guatemala continues to suffer the after effects of a 36-year long civil war, which contributes to stark income equality, little to no educational opportunity, high prices for nutrient-rich foods, and non-existent infrastructure. There is limited access to clean running water, and nearly non-existent sanitation in many areas of the country.[13] Poverty and inequality in both social and political infrastructure leave an unintentional space for Neglected Tropical Diseases (NTD) to persist, especially in rural and indigenous populations where clean water and sanitation are non-existent. This creates a favorable environment in which infectious diseases can thrive, and household conditions may be important factors in the spread of disease.[14] One of the NTD's occurring in Guatemala that directly affects nutritional status of children and women of reproductive age is soil-transmitted helminths (STHs), which are transmitted to humans through soil, vegetation, food, and water that are contaminated by fecal matter containing the eggs and infective larva of the parasites.[15] STHs can divert nutrients from the body, causing intestinal blood loss which results in anemia. This is particularly concerning since anemia can result in intrauterine growth restriction (IUGR) in pregnant women, and these undernourished women who are undernourished are likely to have an undernourished and stunted child. [11,12] It is imperative to interrupt the cycle of malnourished mothers because stunting can lead to lower productivity and delayed development, along with a higher risk of cardiovascular disease, obesity, and diabetes later in life.[11] The unending cycle is this: malnourished mothers give birth to malnourished babies who then may grow up to be malnourished mothers themselves, remaining in continued poverty and

social inequality in a country that is already challenged to repair itself. In order to treat STH's, the World Health Organization (WHO) recommends anthelmintics for women in their 2nd and 3rd trimester of pregnancy, thereby working to increase nutrient absorption and potentially reduce anemia in pregnant women.[16] Currently, there is little to no literature found on the effects of deworming during pregnancy, particularly related to the growth of the child. The objective of this study is to evaluate whether women who received an anthelmintic in their 2nd or 3rd trimester of pregnancy were less likely to have a child that is stunted compared to the women who did not take an anthelmintic during pregnancy.

Methods

The data for this study were collected by the Demographic and Health Surveys (DHS) Program in Guatemala. This household, cross-sectional survey was administered to 21,383 households in Guatemala from October 2014 through June 2015. This survey collects population level information such as social, demographic, self-reported health data, and anthropometry data. The target population for DHS is all women of reproductive age (15-49 years old), and their children (under five years of age) living in ordinary residential households. The survey is conducted using a stratified two-stage cluster design and the sample is representative at the national, regional, and residential levels.[17] The DHS program obtained permission form the Guatemalan government to administer this survey and obtained informed consent by all participants. Permission was granted to use this dataset for analysis from the DHS program. This study was reviewed and approved by the Institutional Review Board (IRB) at Emory University, Atlanta, Georgia.

The mothers that participated in the interview were asked whether they received anthelmintic treatment during pregnancy for their most recent live birth that occurred within in the last 5 years. Women were not asked about the specific anthelmintic treatment that were administered during the pregnancy, nor were they asked about when in gestation that the treatments were given, or if there were multiple treatments with anthelmintics any time during the pregnancy. Missing values on key components of antenatal care (e.g. anthelmintics) are excluded from numerators but included in denominators, assuming that the woman did not receive this antenatal care component.[18] Childhood stunting, a measure of chronic nutritional deficiency, was determined using a child's height for age z-score. The DHS survey uses the WHO's standard measurement of anthropometric z-scores, which were calculated using height in centimeters and age in months.[18] Living children in the household, born 0-59 months before the survey, were measured. Stunting was categorized as follows: moderately to severely stunted: height-for-age z-score is 2-3 standard deviations (SD) below the mean; and not stunted: height for age z-score that is no less than 2 stand deviations below the mean. [18] Children with implausible or missing values were excluded from the analysis. [18] In order to evaluate the association between maternal anthelmintic treatment and stunting in her offspring, the analysis are restricted to include only the youngest child in the household since the survey only asked about use of anthelmintic use during the most recent pregnancy. Twins and triplets in the mother's *most recent* pregnancy were excluded from the analysis since growth patterns in multiple births may differ. If the mother's most recent offspring did not survive, the child was also excluded from the analysis. Data analysis was performed with SAS version 9.4. To account for the complex survey design, the PROC

SURVEYLOGISTIC function was used within SAS for multivariate logistic regression and to obtain odd ratios (ORs) with 95% confidence intervals (CIs). Collinearity diagnostics were performed, as were likelihood ratio tests to assess the presence of interaction by the mother's stunting status, place of residence (rural versus urban), and ethnicity.

Results

Demographic characteristics of the children in this study and their mothers (n=16,502) are represented in Table 1. The percentage of the children that were moderately to severely stunted in this study was 44%. Of the mothers in the study, 6.4% reported that they received anthelmintic treatment during their most recent pregnancy. Children who were stunted tended to be younger, and have mothers who were categorized as being stunted. Sex proportions were evenly distributed 8558 (51.8%) male and 7944 (48.2%) female. Of those with available data, stunting was identified in 571 (46.2%) of female children and in 665 (53.8%) of male children. The frequency of stunting in the children whose mothers were not dewormed was 92.5% and the frequency of stunting was 7.5% in the children whose mothers were dewormed. Because STH's can epidemiologically be related to the environment, household characteristics are also described in Table 1.

Collinearity diagnostics suggested that there was no evidence of collinearity among the predictors considered. There was no evidence of interaction by maternal deworming and mother's ethnicity or the mothers stunting status however, the association between maternal deworming and stunting did differ for those living in rural versus urban areas. The final model adjusted for the mother's age, education level, ethnicity, place of

residence, type of household sanitation, household floor substrate, and household wealth index. There was no association between child stunting and maternal deworming in urban areas (OR, 0.67; 95% CI, 0.28-1.57); however, there was an association between child stunting and maternal deworming in rural areas (Table 2). In rural areas (OR, 2.03; 95% CI, 1.03-4.01), children of mothers who received anthelmintics were two times more likely to be stunted than the children of women who did not receive anthelmintics during pregnancy.

Discussion

The intent of this study was to examine whether there was an association between receiving anthelmintics in their 2nd or 3rd trimester of pregnancy and stunting in the offspring. We did not find an association between a mother receiving an anthelmintic in pregnancy and child stunting status in urban areas; however, deworming was associated with a greater likelihood of stunting in rural areas.

This study is not without limitations. As shown in Table 1, the survey had a considerable amount of missing data. Because height is a key component for calculating a height for age z-score and a large number of the children did not have this measurement, this could have biased the results of the analysis. Although, the period from 6-24 months of age is the time of peak stunting prevalence in developing countries, the majority of children in our analysis were aged 0-12 months. Additionally, this study only included the youngest surviving child in the household because the mother was asked about deworming in her *last* pregnancy. This study is cross-sectional, so it does not include retrospective information on the deceased children in the household, nor does it include stunting status in the children of multiple births since growth patterns could differ in

these siblings and introduce bias. However, if we had information for all of the children in the household, we could compare the deworming status of the mother during pregnancy to the stunting outcome of all of the mother's offspring.

Additionally, a very small percentage of women that received anthelmintics (6.3%) and this question had a high frequency of missing data (*missing data=7300*). The prevalence of anthelmintic use is lower than what we would have expected and it is unknown if there are differences in reporting by factors that would influence the results. It us unknown whether these data are missing because the women were not asked about deworming status, it they did not understand the question, or if it is missing for other unknown reasons. For those that did respond, it is unknown whether the women that were interviewed have a true knowledge or understanding of what medications or supplements were prescribed to them during pregnancy, which could have led to misclassification. Since there are many indigenous communities in Guatemala, it should be considered that misclassification could have occurred, especially in rural areas, where there could have been language differences between the interviewer and the respondent.

These results should be interpreted with caution since maternal and childhood malnutrition can be multifaceted. We do not know whether there are other determinants that led children living in rural areas to become stunted, even when the mother received anthelmintics during pregnancy. Because STH infection is a result of living in areas where there is poor sanitation infrastructure, especially in rural areas, it is possible that women could be co-infected with a parasite (polyparasitism) that standard anthelmintics may be effective against, yet causing symptoms leading to maternal malnutrition. The children in this study could have also become infected with their own parasite burden

after birth since the mother and child typically share the same infective environment. Since the prevalence of STH's in the areas where this survey was administered and the deworming frequency are unknown, it is possible that the mothers could have become re-infected with STH's post-treatment, leading to continued poor health and malnutrition. It is also unknown whether deworming programs have been targeted to the most endemic areas for STH's or in areas of severe cases of malnutrition, and if health care providers in endemic areas place emphasis on using anthelmintics as part of routine antenatal care. Other considerations into the causes of child stunting, even when the mother received anthelmintics in pregnancy, could be inadequate supplemental feeding of the child, short inter-pregnancy intervals disrupting exclusive breast feeding, and recurrent infections outside of parasitism.[19] Based on the results of this analysis, some might consider recommending against administering anthelmintics to pregnant women because of the finding that stunting increased with their use in rural areas. However, it is important to consider these results in the context in which anthelmintics have been used. There are known benefits of using anthelmintics during pregnancy in high burden areas. Further study is warranted to determine whether any potential risk in increased stunting outweighs the benefits of interrupting STH transmission.

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Tables

Table 1: Characteristics of the youngest children in the household, Guatemala, Central America - Demographic Health Survey (DHS) 2014-2015

	All youngest children in household (n=16,502) **13,683 children had missing values for height and weight*	Children with normal height for age (n=1583)	Children with moderate to severe stunting (n=1236)
Child Characteristics			
Age			
0-12 months of age	14,238 (86.6%)	1345 (84.0%)	1030 (82.3%)
13-24 months of age	2184 (12.9%)	231 (15.3%)	202 (17.2%)
25-36 months of age	80 (0.5%)	7 (0.7%)	4 (0.5%)
mean=5.7 months (5.6)			
Sex			
Male	8558 (51.8%)	794 (51%)	665 (53.8%)
Female	7944 (48.2)	789 (49.0%)	571 (46.2%)
Weight (kg)			
2-10 kg	963 (34.4%)	480 (30.9%)	479 (39.0%)
11-18 kg	1800 (63.3%)	1043 (65.4%)	756 (60.8%)
over 19 kg	67 (2.3%)	60 (3.7%)	1 (0.2%)
mean=12.3kg (3.5)			
Height (cm)			
40.0-60.0 cm	130 (5.0%)	76 (5.3%)	54 (4.6%)
61.0-80.0 cm	766 (26.6%)	382 (23.5 %)	383 (30.8%)
80.0-120 cm	1933 (68.4%)	1125 (71.2%)	799 (64.6%)
mean=85.5cm (12.6)			
Mother had anthelmintics in pregnancy			
No	8596 (93.6%)	797 (94.0 %)	598 (92.5%)
Yes	606 (6.4%) *missing=7300*	46 (6.0%) *(missing =740)*	48 (7.5%) *(missing=590)*

Table 1 (continued): Maternal and household characteristics of the mothers of the youngest children in the household, Guatemala, Central America - Demographic Health Survey (DHS) 2014-2015

	Mothers of all youngest children in household (n=16,502) *observations with missing values=13,683	Mother's of children with normal height (n=1583)	Mothers of children with moderate to severe stunting (n=1236)
Mother's Age			
15-25 yrs	1281 (22.8%)	457 (28.4%)	357 (30.4%)
26-35 yrs	2075 (37.2%)	700 (45.0%)	525 (42.3%)
>35 yrs	2194 (40.0%)	408 (26.6%)	346 (27.3%)
mean 32.8 years (8.8)			
Ethnicity			
Maya	6034 (39.0%)	606 (30.1%)	459 (30.4%)
Ladina	10288(60.3%)	966 (69.4%)	766 (69.0%)
Other	180 (0.7%)	11 (0.5%)	11 (0.6%)
Education Level of Mother			
Uneducated	468 (15.7%)	164 (9.1%)	303 (24.7%)
Primary	1416 (49.9%)	725 (44.8%)	688 (57.1%)
Secondary	739 (29.6%)	552 (39.4%)	183 (16.2%)
Post-Secondary/University	117 (4.8 %)	90 (6.7%)	24 (2.0%)
Mother's height for age standard deviation			
Normal height	5003 (28.9%)	499 (34.7%)	392 (33.5%)
Moderate to severe stunting	11,499 (71.1%)	1084 (65.3%)	844 (66.5%)
Type of place of residence			
Rural	3644 (51.7%)	859 (53.1%)	915 (70.7%)
Urban	3019 (48.3%)	724 (46.7%)	321 (29.3%)
Wealth Index			
Poor	6366 (37.6%)	389 (17.7%)	318 (22.5%)
Middle	3410 (20.2%)	341 (19.2%)	276 (20.5%)
Rich	6726 (42.2%)	853 (63.1%)	642 (57.0%)
Source of Sanitation			
Flushed (sewer system/septic tank)	9053 (56.0%)	1038 (72.4%)	836 (71.3%)
Latrine	6112 (38.0%)	480 (25.0%)	355 (26.2%)
No facility/bushes/field	1144 (6.0%)	48 (2.6%)	33 (2.5%)
Type of Floor Substrate			
Dirt	5065 (31.0%)	310 (16.2%)	243 (18.4%)
Finished (wood/vinyl/cement/ceramic tile)	11,235 (69.0%)	1252 (83.8%)	978 (81.6%)

Table 2: Association of maternal deworming and child stunting by place of residence - Demographic Health Survey (DHS) 2014-2015

Place of Residence	Adjusted Odds Ratio	95% CI's
Urban	0.67	(0.28-1.57)
Rural	2.03	(1.03-4.01)

* Adjusted for the mother's age, education level, ethnicity, place of residence, type of household sanitation, household floor substrate, and household wealth index.

Chapter III: Conclusion

Since Soil- transmitted helminths (STH's) have detrimental effects for women and children and infection can proliferate at a community level, a multifaceted approach for prevention and treatment must be established and consistently carried out. While it is difficult to address the long-term solution of improving sanitation infrastructure in impoverished areas, STH infections need to be addressed through routine anthelmintic treatments to interrupt the cyclical process of stunting and continued inequality in developing countries like Guatemala. Despite the findings among rural residents that suggested that anthelmintic treatments were associated with an increased likelihood of stunting in the offspring, it is widely known that anthelmintics are effective in eliminating STH's infection that leads to nutrient loss, anemia, and subsequently malnutrition. If there is an absence of sanitation infrastructure and hygiene is not improved, re-infection with STH's is inevitable. Carefully designed, prospective studies are needed to better understand the association between anthelmintic treatment in pregnancy and child stunting. Because this study is a cross-sectional study design, it is difficult to see the complex associations with maternal and child health. While waiting for long –term solutions to improve sanitation infrastructure, public health programs should focus on interventions that include disease risk reduction by improving hygiene behaviors, routine and consistent child measurements to detect stunting early, nutritional support for women and children, anthelmintic treatments as a part of routine antenatal care, and routine deworming of children, especially targeted to communities with high STH prevalence.