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The Double Burden of Malnutrition: Lifestyle and health factors associated with anemia in children aged 6-59 months and excess weight among women of reproductive age within the same household in Guatemala

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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 Global Epidemiology

2019

Abstract

The Double Burden of Malnutrition: Lifestyle and health factors associated with anemia in children aged 6-59 months and excess weight among women of reproductive age within the same household in Guatemala

By Gauri Adettiwar

Background: Developing countries such as Guatemala are undergoing a rapid nutritional transition. As the prevalence of obesity has increased, the double burden of malnutrition (DBM) has become a public health problem as prevalences of stunting and anemia remain high.

Objective: The aim was to describe the household and nutritional factors associated with maternal figure excess weight and child anemia, and the coexistence of both types of malnutrition in a single household.

Methods: This study used 466 woman and child pairs from the 2016 SIVESNU national survey in Guatemala. A woman was considered a maternal figure as she might not have been the biological mother of the child. Child anemia was described as hemoglobin levels <11 g/dL. Maternal figure excess weight is defined as a Body Mass Index $\geq$ 25 k/m^2. Pairs were categorized into four groups: ACOW (anemic child and overweight woman), ACNW (anemic child and normal weight woman), NCOW (non-anemic child and normal weight woman), and NCNW (non-anemic child and normal weight woman. Multivariable logistic regression models estimating unadjusted, adjusted, and mutually adjusted prevalence odds ratios for both child anemia, and excess weight in women were calculated. Based on a priori identified predictor, pairs of different malnutrition burdens were then compared.

Results: ACOW was identified in 2.8% of the households (n=14). Double burden was more common in urban households, households of higher socioeconomic status, households that had a non-indigenous woman, households that had a child with a recent incident of diarrhea (at most 15 days before the survey), and households where the child was not vaccinated for Hepatitis B at birth.

Conclusions: Our findings support further studies using larger samples to investigate the role of area of residence, socioeconomic status, ethnicity, and health status of the child on the double burden of malnutrition in Guatemala.

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Background

Global Nutritional Transition

Nutritional transition refers to the shifts in dietary patterns and physical activity that are driven by socioeconomic and cultural factors - examples of this would be the introduction of agriculture in early human history, and industrialization more recently (1). Currently, global diets are shifting away from locally available grains, fruits, and vegetables towards processed foods which are low in fiber and high in fat and sugar. This nutritional transition is reflected in changing overall body compositions such that higher rates of overweight and obesity are reported worldwide. While it has been suggested that the over 3 billion people are expected to be overweight or obese by 2030, some studies suggest that there are over currently 2 billion people who are either overweight or obese, and the count is expected to rise drastically in the next decade (2).

Developing countries such as Guatemala are experiencing the nutritional transition at a much faster rate than developed countries, which have been experiencing this transition for over half a century (3). In higher income countries, undernutrition is not considered a major public health concern unlike rising obesity. However, undernutrition and excess body weight coexist in many lower/middle income countries including majority of Latin America (4). It has been estimated that a 10% increase in Gross Domestic Product (GDP) per person globally leads to a reduction in stunting in children by 5.9%, underweight in women by 4.0%, but an increase in overweight/obesity by 7.0% (1). The slower rate of reduction in undernutrition compared to the rate of increase of excess body weight is a likely cause of the coexistence of these conditions, otherwise known as a 'double burden of malnutrition'

(DBM). As such, health policies around the world are beginning to focus on the rising prevalence of overweight and obesity at national levels, while also addressing the existing undernutrition, historically the primary focus of these programs (1).

Malnutrition and the Double Burden

'Malnutrition' refers to nutritional inconsistencies such as nutritional deficiency and/or excess. *Undernutrition* is a component of malnutrition that results from micronutrient deficiencies due to poor absorption, inadequate intake, and insufficient biological use of nutrients that are consumed. *Overnutrition* is a component of malnutrition that occurs when macronutrient intakes become excessive or imbalanced, which can impair bodily functions and contribute to overweight and obesity (3). Both under- and overnutrition lead to negative consequences on a physical level, but can impact household health and can burden a country's economy due to higher health care costs and loss in Gross Domestic Product (3).

Malnutrition in Guatemala

Approximately one-third of Guatemalan children are malnourished nationwide according to the ENMSI (Encuesta Nacional de Salud Materno Infantil) 2014-2015 national survey - these percentages are higher in indigenous (66%) and rural (56%) populations. Addressing malnourishment in Guatemalan children under the age of 5 years is of critical importance as it deeply affects a child's further health, education, and economic development:

Health Impact: In Guatemala, children who are malnourished are more susceptible to, and can die from common childhood illnesses such as diarrhea and pneumonia. 45% of child deaths in Guatemala are due to malnutrition as an 'underlying cause'. These children are also likely to develop chronic conditions such as heart disease during adulthood.

Educational Impact: Malnourished children are more likely to perform poorer in school than their well-nourished counterparts. have impaired cognitive functions, learn to sit, stand, and walk later, miss more days and perform of school, have poorer cognitive function; perform worse in school; are more likely to repeat grades; miss more days of school due to illness; and are more likely to drop out of school than well-nourished children. This can impact future generations - 60% of Guatemalan children whose parents did not complete primary education are stunted compared to 20% of children whose parents completed at least primary education (5).

Economic Impact: Malnourished communities are far more likely to witness reductions in productivity, slowed economic growth and poverty perpetuation. Although Guatemala has the highest GDP in the region, it also had the highest rates of malnutrition according to the 2000 ENSMI. This represents socio-economic and geographic inequality, furthered by income gaps and inter-generational effects (5).

Key indicators of nutritional status

Malnutrition can occur due to a lack of macronutrients (protein, fat, carbohydrates) or micronutrients (vitamins and minerals). Macronutrient malnutrition occurs when the body adapts to reduced macronutrient intake by decreasing physical activity and using energy reserves in the body (6) . Micronutrient malnutrition is due to inadequate amounts of essential vitamins and minerals, mostly due to diet. Biochemical indicators are used to assess common signs of malnutrition such as iron deficiency (anemia), Vitamin A deficiency (xeropthalmia/blindness), iodine deficiency (goiter and cretenism), and deficiencies of Vitamin C, thiamin, and niacin (6).

Iron Deficiency, Anemia, Iron Deficiency Anemia

There are many mild-to-moderate forms of iron deficiency that occur before the development of iron deficiency anemia. 'Anemia', 'iron deficiency', and 'iron deficiency anemia' are often used interchangeably because anemia is the most common indicator, and the most common consequence, of iron deficiency (7).

Iron deficiency: It is widely accepted that iron deficiency is one of the most common nutritional deficiencies in the world, affecting approximately one out of every four people. Causes of iron deficiency include lack of bioavailability and periods of rapid growth like pregnancy or infancy. Another common cause is increased blood loss, such as gastrointestinal bleeding due to hookworm or schistosomiasis related urinary blood loss (7). Patients with inflammatory conditions such as chronic heart failure, chronic kidney disease, and inflammatory bowel syndrome are predisposed to iron deficiency as well. WHO defines low serum ferritin as <15 µg/L in adults and <12 µg/L in children, and the cutoffs rise to <100 µg/L for those with the inflammatory conditions mentioned (8).

Anemia: Anemia is defined as hemoglobin levels less than 13 g/dL for men and 12 g/dL for non-pregnant women (11 g/dL for pregnant women). There are a variety of causes that may be coexisting – nutritional deficiencies in vitamin B12, vitamin A, folic acid, and iron; chronic infections such as malaria or worm infestation; severe blood loss or genetic abnormalities such as thalassemia (7, 10). Children younger than 24 months are especially at risk for anemia as it has been linked to high infection risk and mental and psychomotor development at varying degrees, only partially reversible during adulthood. In older children, the ability to concentrate and perform well in school is hindered. Long term consequences of anemia during infancy include compromised social interaction and lower work productivity (11). Clinical pallor of the nails and eyes used to be considered a useful way to diagnose severe anemia, but due to the variability and subjectivity of the diagnosis, this method is not preferred (7, 12). Instead, a photometer can be used to measure hemoglobin levels in the blood more accurately. Hemoglobin cutoffs have been internationally determined and are as follows:

Table 1. Hemoglobin cutoffs to define anemia in individuals living at an altitude <1000 m

Age in years and sex	Hemoglobin cutoff (g/dL)
Children (both sexes)	
0.5 < age < 5.0	11.0
5.0 < age < 12.0	11.5
12.0 < age <15.0	12.0
Non-pregnant females > 15.0	12.0
Men > 15.0	13.0

Adjustments to hemoglobin cutoffs for pregnancy, altitude and cigarette smoking range from -1.5 (second trimester pregnancy) to +6.7 (5250 <m above sea level).

Iron Deficiency Anemia (IDA): This is anemia that is known to be caused by iron deficiency, which is over 50% of all anemia cases (13). The diagnosis of iron deficiency anemia includes low levels of both hemoglobin and iron stores.

The World Health Organization (WHO) recommends using common indicators such as anthropometric measurements of age, height, weight, and sex to determine stunting (low height-for-age, chronic malnutrition) and wasting (low weight-for-height, acute malnutrition) in children. Body Mass Index (BMI) is an indicator for adults that uses weight-for-height by age (Blossner, 2005). The cutoff categories for different weight categories recommended by the WHO are:

Table 2. Weight classification by BMI levels in women

Severely Underweight	<16 kg/m^2
Underweight	18.5 kg/m^2
Normal weight	18.5 - 24.99 kg/m^2
Overweight	25 - 29.99 kg/m^2
Obesity, grade I	30-34.99 kg/m^2
Obesity, grade II	35-39.99 kg/m^2
Obesity, grade III	>40.00 kg/m^2

An adult is considered to have mild malnutrition if their BMI is less than 18.5 and equal to greater than 17. Moderate malnutrition occurs at a BMI between 17 and 16 (inclusive), and severe malnutrition occurs when an adult's BMI is less than 16 kg/m^2. BMI is a commonly used indicator, but it is limited by general trends and is not capable of distinguishing type of weight (muscle/fat/bones/organs) in a person. Someone like an athlete who has a lot of muscle may have high BMI due to muscle weight and may not be obese even if their BMI reads as such (6). While there are better instruments that separate these weights, the BMI is widely used due to the generalizability and easy application in global settings without the need for expensive technology.

Relevant nutritional indicators in Guatemala

Female Overweight/Obesity: The WHO country profile for Guatemala (2016) states that 52.1% of women and 43.1% of men were overweight and 21.2% of women and 11.3% of men were obese (14). However, the WHO Nutrition Landscape Information System states that 59.9% of women are overweight or obese for the same year (15). The inconsistency in the data could be due to multiple reasons, but there is consistent evidence indicating that the prevalence of overweight and obesity has been increasing over the past decade (15). Prevalence of obesity in 2014 in non-pregnant women of 15-49 years is 25% or above in the Metropolitan region (25.8%), Central region (25.0%), and Peten (25.7%) (16). Although prevalences are for 2014, these regions have had the highest prevalences in 1995, 1998, 2002, and 2008, and it can be assumed that these regions presently have the highest prevalences of obesity in Guatemala as well (16).

Childhood anemia and IDA: The prevalence of childhood anemia (6-59 months) was 32% in 2014-2015, which is much lower than the 48% previously found during the 2008-2009 ENSMI survey (17). This prevalence is close to the average of 33% for Latin American and Caribbean countries (11). Globally, there seem to be no difference in anemia prevalences by gender in children under 13 years of age, but rural areas have higher prevalences of childhood anemia than urban areas (11). There are currently no studies that include IDA directly, but the anemia status can be assumed to be due to iron deficiency given the extensive proportion of anemia that is known to be iron deficiency related.

Current Double Burden of Malnutrition in Guatemala

The evolution of double burden at the household level in Guatemala has been increasingly receiving attention within the past decade. Due to its recent emergence as a public health concern, limited amounts of scientific literature have been published. However, the coexistence of maternal overnutrition and child undernutrition in the same household was shown in the same households in Brazil (11%), China (8%), and Russia (6%) (18). DBM has been recorded as early as the 1970's in Manaus in the Brazilian Amazon, which found

60% stunting in preschool children, 60 % maternal anemia, and 30 percent maternal overweight/obesity (3).

The current literature available in English mostly describes DBM at on a global scale with discussion surrounding more general national population specifics rather than those specifically at the household level (1). Kroker-Lobos et al. evaluates the double burden of malnutrition at the three different levels in Mexico using the indicators for anemia and stunting, and overweight/obesity in all age groups of women and children (4). Contrary to expectations, the authors conclude that the occurrence of stunting/anemia/excess weight was independent and did not influence the occurrence of other conditions in the same household or individual (4).

In reviewing the literature surrounding the double burden that exists specifically in Guatemala, much of the research conducted has evaluated double burden through the lens of stunting and overweight at the individual, household, and population level. This is because stunting is considered a good indicator of chronic malnutrition, and Guatemala had the second highest level of stunting in the world among children < 5 years of age even though it has one of the strongest economies in Latin America (1, 11, 19). However, studies looking at direct micronutrient malnutrition (such as iron deficiency anemia) in conjunction with overweight/obesity in Guatemala are lacking.

Jounghee Lee et al. published a study in 2010 that evaluated the nutritional factors and household characteristics that were related to childhood stunting and maternal excess weight at the household level (20). They found DBM in 18% of the households, and that the socioeconomic status of these households was significantly lower than those that did not have stunted children. They also identified maternal short stature, higher parity, current work status, and self-identified indigenous ethnicity as predictors of this particular DBM (20). The study concluded by reiterating that this specific DBM disproportionally affects disadvantaged population groups in a country that is going through a nutritional transition. They theorized that these groups have disease associated with low physical activity and cheaper processed foods that are high in dietary energy and low in nutritional value (20). However, this study did not collect data on physical activity or diet, or even changes in household conditions to support this conclusion. They also did not evaluate data related to household expenditure, or foods that were eaten outside the home. In keeping with the dietary assumptions, it is possible that the measured associations are biased towards the null.

Another study was done in 2014 by Manuel Ramirez-Zea and his co-authors, including Maria Kroker-Lobos, that looked at how this DBM is different in indigenous and non-indigenous populations at multiple levels, and how the prevalences have changed from 1998 to 2008 using three ENSMI survey data (19). When comparing the two populations, there was less excess weight amongst mothers that were indigenous compared to those that weren't, but there was significantly more stunting amongst children. They concluded that DBM at the individual and household level was greater in indigenous populations, and geographical areas that were predominantly indigenous as well (19).

This study had a heavy emphasis on stunting and excess weight, but anemia was also analyzed. They did not find a significant difference in anemia in children based on their ethnicity, but the same cannot be said for the women of reproductive age. The prevalence of anemia was significantly higher in indigenous women ages 15-49 compares to non-indigenous women of the same age. Within the indigenous group itself, women over the age of 35 had 7.5% percentage points higher compared to those under 35, whereas the difference in the non-indigenous group by age was only 3.2% percentage points in comparison (19). The study only considers two groups of women's age for analysis, but the results could be more informative if the age categorizations were more specific – for example, ages 15-20, 20-35, 35-49 may capture differences in adolescents, young adults, and mature adults more specifically when stratified by ethnicity. The authors also conclude that DBM at the household level occurs 'solely' due to the separate prevalences of individual conditions (anemia/stunting/excess weight) because the observed prevalences were less than the expected, but this can be further explored (19).

Data

All studies included that look at nutritional status in Guatemala at the national, household, and individual level use ENMSI data, with the most recent one being from 2014-2015. The ENSMI is produced by the Guatemalan government and the Institute of Nutrition of Central America and Panama, following the methodology behind Reproductive Health Surveys (21). Included are questions about individual and household demographics, infectious disease, anthropometric measurements with a heavy emphasis on sexual, reproductive, and maternal health. Data on food consumed by the individual is collected (both fortified and non-fortified) but no micronutrient specific data such as Vitamin A, or iron levels are measured. Only hemoglobin levels are read and adjusted for altitude, and blood for HIV testing is collected (21). Hence, there is no way to test the causes for anemia using this survey, only its presence.

Introduction

The contradictory phenomenon of the coexistence of maternal excess body weight and child undernutrition is a growing global public health concern, particularly in Guatemala. The "double burden of malnutrition" (DBM) at the household level has been evaluated globally, however, these results are based on child stunting and maternal excess weight (1, 22, 23). Kosaka and her co-author Umezaki recently reviewed this mother-child double burden within the household level in 57 countries using each country's latest national data, and found that while most countries had <10% prevalence of child stunting and maternal excess weight, Guatemala had one of the highest prevalences (10-20%) based on studies utilizing national surveys (1, 24, 25). These studies mostly analyze chronic malnutrition and excess weight, and their associated factors at the individual, household, and national level. There is a lack of published literature looking at the specific double burden of anemia in young children and excess weight in mothers, specifically in Central America in recent years.

Anemia affects 1.62 billion people worldwide (11). Young children in developing countries are especially vulnerable to anemia, mostly due to iron deficiency (IDA). Studies using the ENSMI national survey indicate that the prevalence of anemia in children aged 6-59 months went from 39.7% in 2002 to 47.7% in 2008 (11). This prevalence decreased to 32.40% (95% CI: 31.5, 33.27) in 2014-2015. However, the prevalence of anemia in Guatemala is still higher than the average of 22.52% (95% CI: 15.05, 29.8) for Central America. Anemia during childhood has been positively associated with growth delay, higher risk of infections, poorer cognition and motor development when compared to children without anemia, and long-term consequences include lower quality of life and lower work productivity (11). Both anemia and excess body weight in low and middle-income countries have complex etiologies with multiple factors contributing to their development. Identifying these factors within the household setting can help inform integrated and innovative prevention strategies and health policies specific to anemia and maternal excess weight.

Those of indigenous ethnicity represent only 5% of the global population but represent 15% of those in poverty, and have a life expectancy 20 years less than non-indigenous populations. Guatemala is a heavily diverse country with approximately 40% of the population of indigenous descent, with over 23 languages spoken (19). Although Ramirez-Zea et al. concluded that anemia amongst Guatemalan children was not significantly different based on ethnic status, there are multiple studies conducted internationally that indicate that ethnicity is a strong predictor of childhood anemia (1, 26). To create nutritional policies that are nationally effective in Guatemala, ethnic diversity must be considered when addressing DBM.

Multiple studies associate socio-economic status, maternal stature, maternal employment status, higher parity, and self-identified indigenousness were significantly different in households that have stunted children and overweight/obese mothers compared to households that had normal-statured children and normal weight mothers (19, 20). Although these predictors are in relation to stunting, they can be assumed to affect anemia as well. This is because stunting is a product of chronic malnutrition, which can include iron deficiency.

This study will evaluate the predictors of the double burden of childhood anemia and maternal-figure excess weight at the household level in Guatemala. The role of self-identified indigenousness for this DBM will be investigated due to Guatemala's immense diversity and the importance of indigenous inclusion in health policy. Based on the results of this study, further recommendations for existing programs and policies will be provided after summarizing the current strategies that aim to tackle the double burden childhood anemia and maternal excess weight.

Methods

The data used for this analysis comes from the 2016 Health and Nutrition Surveillance System (SIVESNU in Spanish), which is considered a valuable instrument for monitoring and evaluating the Guatemalan government's multi-sectoral nutrition approach (USAID, 2018). SIVESNU uses a complex survey design to get a representative sample of the Guatemalan population. Nutritional biomarkers such as ferritin levels, hemoglobin levels, anthropometric information, demographic information, diet and lifestyle, consumption of fortified goods, and household characteristics such as presence of a television and plumbing are included in this survey.

The term 'woman' will be used to refer to the maternal figure of the household that was interviewed, as they may not be the biological mother of that child (grandmother/aunt/etc.).

For this analysis, 961 children of age of 6-59 months, 1763 women from ages 15-49 years, and 2377 households were considered. Children who did not have a unique identification value for their household were excluded (n=363). Underweight (BMI <18.5 kg/m^2) women were excluded (n=10) because only normal weight or overweight women are compared, and this exclusion avoids potential issues with the interpretation. A final total of 466 woman-child pairs were identified, as many households did not have both woman and child information collected from the same household.

<u>Outcome measures</u>

Anemic status of children 6-59 months was determined by hemoglobin levels less than 11 g/dL, after adjusting for altitude. Women from the same households were categorized by Body Mass Index (BMI), and were divided into two groups: overweight (BMI ≥ 25 kg/m^2) or normal weight (18.5 $kg/m^2 \leq$ BMI < 25 kg/m^2).

Woman and child pairs are categorized into one of four groups as follows: Anemic child and overweight woman (ACOW); Anemic child and woman with normal weight (ACNW); Non-anemic child and overweight woman (NCOW); and Non-anemic child and woman with normal weight (NCNW).

Exposure measures

The survey classifies the ethnicity of the woman into 3 groups: Indigenous, Ladina (Spanish heritage), and other. For this study, ethnicity was further dichotomized to either indigenous, or non-indigenous (Ladino, other) based on a self-identification in the survey. Socioeconomic status (SES) was also dichotomized into 2 groups: low / middle, and high SES. Low and middle SES was grouped together as preliminary analyses showed no significant or meaningful difference between the two groups. The area of residence was treated as a dichotomous variable as either urban or rural.

In this analysis, the child's gender was adjusted for, but not included as a predictor as anemia status does not seem to significantly differ by gender in children less than 12 years of age based on existing literature (27). Only 11 of the 466 children had Iron Deficient Anemia, so anemia measured by hemoglobin levels (< 11 g/dL) as the outcome identifier. Recent child diarrhea was used as a proxy for the child's health status. If the child was reported as having diarrhea within 15 days of the survey, it was recorded as a dichotomous variable (yes or no). The child's vaccine status was a proxy used for overall child health status as well as a proxy for woman's health-conscious behavior. A child was originally considered vaccinated if they received all vaccines required for their age. However, given the small sample size further reduced by those who did not complete vaccine requirements, a more general vaccine proxy was selected. If the child had been given a Hepatitis B vaccine at birth, the child was considered vaccinated. This vaccine was chosen because it had the most data available, and the only vaccine with which analysis could be conducted on the smallest outcome group (ACOW: n=14).

For the purpose of the analysis, the child's age was categorized as 6-23m, 24-35m, and 36-59m. Children ≤ 5 months were not included in this analysis as complete data was not available for this age category. Whether the child received ferrous sulfate (iron) was taken into consideration, however only 19 of the 466 were given iron so it was not included in the analysis.

The woman was considered short statured if her height was less than 145 cm, following ACC/SCN, 1992 guidelines. For the analysis, the women's age in years was categorized into one of the 3 groups: 15-24, 25-34, 35-49. The use of Chispitas (micronutrient powder containing iron), Incaparina (protein and micronutrient drink containing iron), or VitaCereal (fortified meal) daily was considered. However, based on univariate calculations, woman's short stature, woman's age, and use of fortified foods did not affect either maternal weight or child anemia and were not included in the final logistic models.

Data analysis

Bivariate analyses were conducted to determine relevant predictors of child anemia and woman's excess weight separately. The resulting Chi-square and p values were used in addition to literature findings to inform variables used in the following multivariable logistic regression models predicting unadjusted, adjusted, and mutually adjusted prevalence odds ratios (uPOR, aPOR, mPOR) and associated 95% confidence intervals (CI) of child anemia and woman's excess weight separately. The final predictors included in the analyses were ethnic status (indigenous vs. non-indigenous), area of residence (urban vs. rural), socioeconomic status (low/middle vs. high), whether the child had diarrhea within 15 days of the survey (yes vs. no), and child vaccination status by Hepatitis B vaccine at birth (yes vs. no).

Next, multivariable logistic regressions using the same predictors were used to compare households with no burden of child anemia/woman excess weight (NCNW) to households that had double burden (ACOW). Similar models were used to compare NCNW to the other households with either child or woman outcome: NCOW and ACNW. All analyses were adjusted for the complex survey sampling design. Data analyses was conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC, 2013).

Results

Survey Participant Characteristics

Of the 466 pairs, 51 mothers were missing weight data, and 1 child was missing data on anemia status. Of the remaining 414 pairs, there were 169 (40.8%) NCNW pairs and 14 (3.4%) ACOW pairs. A total of 37 children had anemia, and 226 women had a BMI ≥ 25. As such, a little over half of the households were NCOW (51%) and the remaining were ACNW (4.6%). 61.0% of mother were self-identified as indigenous and 39.0% of the women were non-indigenous. 72.2% of ACOW pairs were indigenous, compared to 61.3% of NCNW pairs (Table 1). 90.0% of NCNW households were rural compared to 72.3% of ACOW households. The NCNW group had the highest proportion of low socioeconomic status households (66.09%), and the ACOW group had the highest proportion of households with a high socioeconomic status (16.67%). Additional details on demographic characteristics can be found in Table 1.

Predictor Identification

The bivariate analyses produced chi-square and p values for the potential predictors that included food security status, child's age, area of residence, socioeconomic status, ethnicity of maternal figure, presence of television or computer in the household, short stature of maternal figure, use of iron fortified meal or micronutrient powder within the household, and whether the child had diarrhea within 15 days of the survey. These values are presented in Table 4. Only two predictors, recent diarrhea and child vaccination status, were statistically significant at alpha = 0.05 for both child anemia and woman's excess weight. In addition, the child's age and area of residence were statistically significant (alpha = 0.05) for child anemia, but not for woman's excess weight. Maternal short stature, socioeconomic status, and presence of television or computer in the household were statistically significant (alpha = 0.05) for woman's excess weight but not for child anemia. It is possible that with a larger sample of children with anemia, more statistically significant predictors could be identified.

Multiple studies have shown that ethnicity, area of residence, and socioeconomic status as related to both maternal weight or child anemia, and were included in the final regression models (1, 11). Whether a child had diarrhea recently or was vaccinated for Hepatitis B were included in the final models as well due to their significant effect on both child anemia and woman's excess weight.

Prevalence Odds Ratios of Predictors - Child Anemia and Woman's Excess Weight

The aPOR for child anemia for each predictor accounted for the child's gender and age, and the aPOR for excess weight in women for each predictor accounted for the woman's age. All POR with 95% confidence intervals for both women and children are shown in Table 2.

Predictors of child anemia

A child aged 6-59 months from a household of high socioeconomic status, or an urban household, has higher odds of having anemia compared to a child from a low/middle socioeconomic status or living in a rural household (Table 2). In addition, if a child has been vaccinated, or had diarrhea within 15 days of the survey, they have higher odds of having anemia. The odds of a child having anemia does not seem to be affected by the ethnicity of the maternal figure.

Because only 37 children had the outcome of child anemia, it is possible that a larger sample size of children might affect the associations and reflect more valid confidence intervals that suggest a stronger positive, negative, or null association. The unadjusted, adjusted, and mutually adjusted models include values that show no statistical or meaningful association between the predictors and child anemia in this population, furthered by the wide confidence intervals that include 1.00 (no positive or negative association) for all three POR's for all predictors.

Predictors of excess weight among maternal figures

Non-indigenous women, women of a higher socioeconomic status, and women who live in urban households have higher odds of having excess weight than indigenous women, women of low/middle socioeconomic status, and women who live in rural households (Table 2). Child's recent diarrhea and Hepatitis B vaccination status were the only predictors that were statistically significant at alpha = 0.05 for all adjusted and unadjusted models for excess weight in women.

Women who had a child in their household that was vaccinated for Hepatitis B at birth have 5.48 (1.29, 23.20) times the odds of being overweight or obese compared to women that did not have a vaccinated child in their household, after controlling for all other predictors as well as the age of the woman. Although this value is statistically significant, a confidence interval that has a width of 17.98 calls into question the validity of this assessment.

Women who had a child in their household that had diarrhea within 15 days before the survey have 3.06 (1.79, 5.22) times the odds of being overweight or obese compared to women whose household did not have a child with a recent diarrhea incident, after controlling for all other predictors and the age of the woman. A confidence interval of 2.92 makes this predictor much more reliable than the other predictors included in this analysis.

Prevalence Odds Ratios of Predictors – Comparing Woman-Child Groups

Double burden (ACOW vs. NCNW)

The weighted frequency of ACOW households was 18.00, and NCNW was identified in 272.00 pairs (Table 3). Households that were in an urban environment or had a higher socioeconomic status have higher odds of having an anemic child and a maternal figure with excess weight compared to households that were in a rural environment or have a low/middle socioeconomic status, after controlling for other predictors (Table 3). In addition, a household that had a child that has not been vaccinated or a child with a recent incident of diarrhea or has higher odds of having the double burden compared to the households that did not have either a vaccinated child or a child without a recent diarrhea incident (Table 3).

If the household had an indigenous woman, the odds of having an anemic child and a maternal figure with excess weight are 1.98 (0.39, 10.26) times the odds of having an anemic child and a woman with excess weight if the woman did not identify as indigenous. However, the weighted frequency of the ACOW group with an indigenous woman was 13.00 pairs and only 5.00 pairs for ACOW without an indigenous woman in the household.

Single Burden (ACNW/NCOW vs. NCNW)

There were a total of 39.00 ACNW and 304.00 NCOW households after weighting (Table 3). When comparing ACNW and NCOW to NCNW households, the associations were in the same direction for all predictors except for child vaccination status; households where the child received the Hepatitis B vaccine at birth have 0.66 (0.19, 2.28) times the odds of having an anemic child and maternal figure with normal weight. However, households where the child was vaccinated at birth have 1.54 (0.96, 2.47) times odds of having an overweight maternal figure and non-anemic child compared to households where the child did not receive the Hepatitis B vaccine at birth.

For both ACNW and NCOW pair types, a child's recent diarrhea incident is the only predictor that does not include a null value in the confidence interval, with a strong positive association between a child with recent diarrhea and ACNW or NCOW.

Discussion

Guatemala previously had the highest reported prevalences in the world for DBM at the individual, household, and national level (19). While many studies emphasized chronic malnutrition measured by stunting, this study sought to enrich our knowledge on the predictors associated with child anemia as one of the DBM outcomes (27). However, due to the lack of surveyed households containing anemic children, we can only speculate the relevancy of these predictors on the double burden.

Of those individuals included in this analysis (n=932), the prevalence of anemia in children (hemoglobin < 11 g/dL) was 8.9%, and the prevalence of excess weight (BMI ≥ 25) in maternal figures was 50.9%. The discrepancy in prevalences is visible in the proportion of woman-child pairs; majority of the pairs were NCOW (48.1%, n= 212), compared to ACOW (2.8%%, n= 14) and ACNW (6.2%, n =19) (Table 1). Because the household group that included the double burden (ACOW) was very small, it is difficult to draw valid conclusions about the effect of factors such as socioeconomic status, ethnicity, age, amongst others, on the outcome. This is numerically demonstrated by the wide confidence intervals of the strength of associations. Furthermore, the width of these confidence intervals prevents us from making any conclusions about the true underlying associations.

This study found double burden was more common in urban households, households of higher socioeconomic status, households that had a non-indigenous woman, households that had a child with a recent incident of diarrhea (at most 15 days before the survey), and households where the child was not vaccinated for Hepatitis B at birth. The same associations were found for homes that only had maternal figures with excess weight. It is possible that given the much higher prevalence of the ‘overweight woman’ in this population, these predictors predict the outcome of overweight woman compared to an anemic child. Interestingly, the association between having a child vaccinated at birth had inverse relationships in ACNW and NCOW groups: the odds if ACNW were less when the child was vaccinated compared to if they were not, but the odds of NCOW were higher when the child was vaccinated compared to when they were not. While these associations control for socioeconomic status, woman's ethnicity, area of residence, and 'child health status' (recent diarrhea), it is possible that these factors could be effect modifiers for this specific relationship, and that the odds stated are not solely reflective of the effect of child vaccination status.

The predictor that had the strongest association with ACOW, NCOW, and ACNW was whether the child had diarrhea within 15 days of survey response. This could be possible because recent diarrhea has been considered a contributing factor of anemia amongst young children in rural environments (28). Diarrhea in children could be representative of folic acid deficiency and zinc deficiency as well, further establishing the undernourished state of the child.

Study Limitations

Iron deficiency is known to be the most common cause of anemia, specifically known as iron deficiency anemia. However, anemia has multiple causes such as malaria, helminth infections such as hookworm, folic acid deficiency and low micronutrient bioavailability (29). Interestingly, less than 50% of the children who were anemic in this population had iron deficiency anemia. Because the number of children with iron deficiency anemia would have been even less than those included in this study, iron deficiency specific anemia was not specifically analyzed. The other causes of anemia in these children were not specified. To target anemia in this population, it would be useful to know what are the other causes of anemia besides iron deficiency.

Using Hepatitis B vaccination status at birth as a proxy for health status is a limitation brought by the lack of enough child participants in the study with anemia. Ideally, a child's vaccination status would include all the vaccines required for the child's respective ages.

Logistically, approximately one third (n=333) of the surveyed children could not be used in this analysis because their data was not linked to a unique household identifier. The exclusion of these children could have possibly contributed to the lack of specificity in the found associations between predictors and group outcomes. Given the small number of children who were anemic in the included population, adding the excluded children could potentially demonstrate stronger and more valid associations. Overall, a higher sample size for both maternal figures as well as children in households would be beneficial to creating stronger relationships.

The maternal figure who was surveyed was not necessarily the child's biological mother. As such, only environmental factors in the child's upbringing such as socioeconomic status and area of residence can be attributed to child anemia. This discounts any associations that could be drawn about any biological reasoning that could cause a double burden. This includes the genetic differences that could affect both anemia and excess body weight – while indigenousness was associated with maternal figure excess weight and child anemia, the association can be speculated to be purely behavioral or cultural with the extent of genetic effect on these burdens remaining unclear.

<u>Study Strengths</u>

This study takes uses a complex survey design analysis. This takes into account the different clusters of households and assigns appropriate weights to individuals, which gives a more accurate picture of the underlying associations. Furthermore, the survey incorporates information from the maternal figure, the child, and the household, creating a comprehensive list of factors to consider. Surprisingly, food fortification did not present any effect on child anemia or maternal overweight. This effect would have been unknown if household consumption information was unavailable. In the same way, the proportion of children with iron deficiency anemia vs. anemia in general would not have been known if the two had not been separated beforehand.

Allowing a maternal figure to be a participant cannot provide biological information related to the outcomes, but it allows the inclusion of households that would have otherwise been excluded. We can get an insight into the exclusive associations that the environment, cultural norms, and household lifestyle in general affects these different outcomes.

Conclusion and Future Directions

This study illustrates lifestyle and health factors that are associated with childhood anemia and overweight/obesity in the child's maternal figure. In future studies, household factors such as socioeconomic status and urban living should be studies further along with the ethnic status of both the child and the maternal figure. When collecting data on the family, a future study can identify the maternal figure as either the child's mother or not to help draw finer conclusions. In the context of the nutritional transition, Guatemala is changing drastically where households are increasingly becoming urban with lifestyle factors changing accordingly (19). With approximately 50% of the women included in this study having excess weight, policies can target obesogenic lifestyles and diets in households affected by this nutritional transition while also keeping in mind the micronutrient requirements needed for both children and adults. Although this study cannot comment with certainty on the proportion of households with double burden, the low prevalences of anemia compared to those found in the 2014-2015 ENSMI provides a positive outlook on current efforts to reduce anemia in children nationally (including food fortification and other national level policies) (30).

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Table 1. Characteristics of Woman-Child Pairs by Woman's Weight Status and Child's Anemic Status Based on 2016 SIVESNU Data

	NCNW (n=169)			ACNW (n=19)			NCOW (n=212)			ACOW (n=14)		
	N	Weighted Freq	%	N	Weighted Freq	%	N	Weighted Freq	%	N	Weighted Freq	%
Child Characteristics												
Age, months												
0-5	2	3	0.46	0	0	0.00	2	4	0.62	0	0	0.00
6-11	14	27	4.15	6	10	1.54	15	22	3.38	2	2	0.31
12-23	38	50	7.69	7	16	2.46	40	54	8.31	5	8	1.23
24-35	39	64	9.85	2	3	0.46	49	73	11.23	2	2	0.31
36-47	44	75	11.54	4	10	1.54	49	70	10.77	2	3	0.46
48-59	42	70	10.77	0	0	0.00	55	81	12.46	3	3	0.46
Child Gender												
Male	82	129	19.82	7	14	2.15	102	155	23.81	6	10	1.54
Female	97	160	24.58	12	25	3.84	109	150	23.04	8	8	1.23
Recent Diarrhea *												
Yes	23	35	12.87	10	20	51.28	65	103	33.77	4	4	22.22
No	146	237	87.13	9	19	48.72	145	201	65.90	10	14	77.78
Vaccinated at Birth **												
Yes	70	105	38.60	7	14	35.90	107	153	50.16	6	7	38.89
No	99	167	61.40	12	25	64.10	104	152	49.84	8	11	61.11
Woman Characteristics												
Age, years												
15-19	36	52	7.99	3	6	0.92	16	27	4.15	1	1	0.15
20-24	45	72	11.06	7	15	2.30	53	75	11.52	5	6	0.92
25-29	36	60	9.22	4	9	1.38	43	63	9.68	4	4	0.61
30-34	29	52	7.99	3	5	0.77	47	67	10.29	3	6	0.92
35-39	18	30	4.61	1	2	0.31	30	45	6.91	1	1	0.15
40-44	10	15	2.30	1	2	0.31	12	14	2.15	0	0	0.00
45-49	5	8	1.23	0	0	0.00	10	14	2.15	0	0	0.00
Ethnic Status												
Indigenous	104	177	61.25	11	23	58.97	120	182	59.67	10	13	72.22
Ladino	70	103	35.64	8	16	41.03	80	106	34.75	4	5	27.78
Other	5	9	3.11	0	0	0.00	11	17	5.57	0	0	0.00
Short stature (<145 cm)												
No	127	194	67.13	14	28	71.79	164	230	75.41	11	15	83.33
Yes	52	95	32.87	5	11	28.21	47	75	24.59	3	3	16.67
Weight category ***												
Underweight	0	-	0.00	0	-	0.00	0	-	0.00	0		0.00
Normal Weight	169	-	100.00	19	-	100	0	-	0.00	0		0.00
Overweight	0	-	0.00	0	-	0.00	148	-	69.8113	10	-	71.4286
Obese	0	-	0.00	0	-	0.00	64	-	30.1887	4	-	28.5714
Household Characteristics												
Area of residence												
Urban	15	25	8.65	5	11	28.21	39	47	15.41	4	5	27.78
Rural	164	264	91.35	14	28	71.79	172	258	84.59	10	13	72.22
Socioeconomic Status												
Low	113	191	66.09	11	21	53.85	100	162	53.11	7	11	61.11
Middle	61	92	31.83	7	16	41.03	91	121	39.67	4	4	22.22
High	5	6	2.08	1	2	5.13	20	22	7.21	3	3	16.67

[a] NCNW (non-anemic child and normal weight woman); ACNW (anemic child and normal weight woman) ; NCOW (non-anemic child and overweight/obese woman); ACOW (anemic child and overweight/obese woman)

[b] Percents are based on totals from all four woman-child group types

[c] 52 woman-child pairs are excluded due to missing values

[d] The total sum of percentages included in the columns may not be 100% due to rounding.

* Recent diarrhea includes any incidence of diarrhea within 15 days before the survey

** Hepatitis B vaccine at birth

***Underweight = Body Mass Index (BMI) < 18; Normal Weight = $18 \leq$ BMI < 25; Overweight = $25 \leq$ BMI < 30; Obese = $30 \leq$ BMI

Table 2. Predictors of Anemia in Children Based on 2016 SIVESNU Data

	Anemia in child		
Predictor	**uPOR**	**aPOR**	**mPOR**
Ethnic Status			
Indigenous	0.87 (0.38, 1.98)	0.85 (0.36, 2.00)	1.01 (0.44, 2.32)
Ladino	1.00	1.00	1.00
Area of residence			
Urban	2.80 (1.07, 7.30) *	3.13 (1.18, 8.29)	2.66 (0.94, 7.53)
Rural	1.00	1.00	1.00
Socioeconomic Status			
Low / Middle	0.36 (0.12, 1.11)	0.41 (0.17, 1.01)	0.62 (0.25, 1.58)
High	1.00	1.00	1.00
Child Diarrhea **			
Yes	1.90 (0.98, 3.66)	1.83 (0.89, 3.75)	1.76 (0.84, 3.71)
No	1.00	1.00	1.00
Child Vaccinated ***			
Yes	1.23 (0.19, 7.77)	1.58 (0.21, 11.97)	1.21 (0.15, 10.05)
No	1.00	1.00	1.00

uPOR: unadjusted Prevalence Odds Ratio, aPOR: adjusted Prevalence Odds Ratio includes age and gender for children, age for women; mPOR: mutually adjusted Prevalence Odds Ratio

* $p < 0.05$

** Recent diarrhea includes any incidence of diarrhea within 15 days before the survey

*** Hepatitis B vaccine at birth

Table 2. Predictors of Excess Body Weight in Women Based on 2016 SIVESNU Data

	Excess body weight in woman		
Predictor	**uPOR**	**aPOR**	**mPOR**
Ethnic Status			
Indigenous	0.94 (0.61, 1.44)	0.87 (0.56, 1.34)	0.84 (0.52, 1.36)
Ladino	1.00	1.00	1.00
Area of residence			
Urban	1.47 (0.85, 2.55)	1.43 (0.81, 2.53)	1.04 (0.50, 2.14)
Rural	1.00	1.00	1.00
Socioeconomic Status			
Low / Middle	0.31 (0.10, 1.04)	0.33 (0.98, 1.09)	0.39 (0.10, 1.52)
High	1.00	1.00	1.00
Child Diarrhea **			
Yes	2.33 (1.43, 3.78) *	2.74 (1.63, 4.60) *	3.06 (1.79, 5.22) *
No	1.00	1.00	1.00
Child Vaccinated ***			
Yes	8.89 (2.32, 34.12) *	9.11 (2.40, 34.59) *	5.48 (1.29, 23.20) *
No	1.00	1.00	1.00

uPOR: unadjusted Prevalence Odds Ratio, aPOR: adjusted Prevalence Odds Ratio includes age and gender for children, age for women; mPOR: mutually adjusted Prevalence Odds Ratio

* $p < 0.05$
** Recent diarrhea includes any incidence of diarrhea within 15 days before the survey
*** Hepatitis B vaccine at birth

Table 3. Mutually Adjusted Prevalence Odds Ratios of predictors when comparing ACOW, ACNW, and NCOW to NCNW Households in Guatemala Based on 2016 SIVESNU Data

	NCNW	ACOW (n=14) compared to NCNW (n = 169)		ACNW (n=19) compared to NCNW (n = 169)		NCOW (n=210) compared to NCNW (n = 169)	
Predictor	**N**	**N**	**aPOR (95% CI)**	**N**	**aPOR (95% CI)**	**N**	**aPOR (95% CI)**
Ethnic Status							
Indigenous	169.00	13.00	1.98 (0.39, 10.26)	23.00	1.01 (0.24, 4.18)	182.00	1.13 (0.68, 1.88)
Not indigenous	103.00	5.00	1.00	16.00	1.00	122.00	1.00
Area of residence							
Urban	25.00	5.00	2.39 (0.25, 22.58)	11.00	2.47 (0.47, 13.00)	47.00	1.12 (0.45, 2.77)
Rural	247.00	13.00	1.00	28.00	1.00	257.00	1.00
Socioeconomic Status							
Low / Middle	266.00	15.00	0.104 (0.01, 1.47)	37.00	0.34 (0.40, 2.84)	282.00	0.23 (0.08, 1.09)
High	6.00	3.00	1.00	2.00	1.00	22.00	1.00
Child Diarrhea**							
Yes	35.00	4.00	2.15 (0.54, 8.55)	20.00	6.77 (2.17, 21.086) *	103.00	3.59 (2.01, 6.40) *
No	237.00	14.00	1.00	19.00	1.00	201.00	1.00
Child Vaccinated***							
Yes	105.00	7.00	0.78 (0.25, 2.39)	14.00	0.66 (0.19, 2.28)	153.00	1.54 (0.96, 2.47)
No	167.00	11.00	1.00	25.00	1.00	151.00	1.00

a NCNW (non-anemic child and normal weight woman); ACOW (anemic child and overweight/obese woman); ACNW (anemic child and normal weight woman) ; NCOW (non-anemic child and overweight/obese woman)

b Weighted frequencies are reported for (N) values for each group

* $p < 0.05$

** Recent diarrhea includes any incidence of diarrhea within 15 days before the survey

*** Hepatitis B vaccine at birth

Table 4. Bivariate analyses for predictor determination for anemia in children 6-59 months and excess weight in maternal figures based on 2016 SIVESNU Data

Predicors	Child anemia		Excess Weight in Woman	
	Rao Scott chi-square	p value	Rao Scott chi-square	p value
Child Age (6- 59 months)	25.8846	<.0001	2.7008	0.6091
Area of residence	5.5888	0.0181	2.6952	0.1006
Socioeconomic Status	3.3131	0.1908	6.7245	0.0347
Ethnicity	0.3818	0.5366	0.0379	0.8457
television/computer	0.0151	0.9023	8.9444	0.0028
maternal short stature	0.2528	0.6151	2.7537	0.097
Incaparina	2.2412	0.6915	-	-
Chispitas	0.102	0.9503	-	-
Hepatitis B (vaccine proxy) ***	11.8371	0.0006	5.0634	0.0542
food security *	1.468	0.6897	0.3954	0.9412
diarrhea **	4.0115	0.0452	13.0671	0.0003

** Recent diarrhea includes any incidence of diarrhea within 15 days before the survey

*** Hepatitis B vaccine at birth