LINKING HOUSEHOLD FOOD INVENTORIES WITH DIETARY RECALLS TO EXAMINE THE ASSOCIATION BETWEEN NUTRIENT AVAILABILITY AND DIETARY INTAKE AMONG MEXICAN-ORIGIN CHILDREN WHO RESIDE IN TEXAS BORDER REGION *COLONIAS*

A Thesis

by

JENNIFER BECKER HUTCHINSON

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2011

Major Subject: Nutrition

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Approved by:

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	William Alex McIntosh
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ABSTRACT

Linking Household Food Inventories with Dietary Recalls to Examine the Association Between Nutrient Availability and Dietary Intake Among Mexican-Origin Children who Reside in Texas Border Region *Colonias*. (August 2011)

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The purpose of this study was to determine the relationship between household food inventories (HFI) and dietary recalls among Mexican-origin children (ages 6-11 years old) who reside in Texas border region *colonias*. Household food availability is a known influence upon children's diets; however, this population faces unique influences upon children's dietary intake and household food availability may not exhibit the same influence upon children's dietary intake that it does in other areas of the United States.

This study utilized *promotoras* (community healthcare workers native to the Texas border region) to collect data from participants due to their rapport with residents of the community. These *promotoras* collected a series of surveys, HFI's and 24-hour dietary recalls with each mother-child dyad participant.

Data from the HFI-s and 24-hour recalls were entered into the Nutrition Data System for Research (NDS-R) from the University of Minnesota and the nutrient profiles for each were analyzed. The HFI data was then adjusted for household

composition to obtain a more accurate representation of what nutrients are available to each specific member of the household.

After analysis, participant children reported living in households with 5.7 adults and children (range 3-10). All children participated in school breakfast and lunch programs. Age- and gender-specific body mass index (BMI) percentiles indicated that 42% were considered overweight or obese. Lower food security was associated with greater energy, total sugar, and added sugar intakes. The largest correlations between HFI's and 24-hour intakes were for total protein, total sugar, sodium, and added sugar. Sodium was the only nutrient with a significant correlation between household availability and children's dietary intake. HFI was independently associated with greater intake of sodium and lower intakes of total sugar and added sugar.

Results show a relationship between household food availability and children's dietary intake. However, at the nutrient level, this association is only statistically significant for sodium and almost significant for total sugar. *Colonia* children are likely eating many meals outside of the home; the traditional HFI might not be useful in determining what foods are available for these children to eat.

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1. INTRODUCTION: BACKGROUND

Obesity is reaching epidemic levels across the United States; rates are increasing steadily with no apparent relief in sight.[1-2] The consensus among researchers is that obesity ultimately results from an energy imbalance: energy intake greatly exceeds energy output.[3] When a high energy intake is coupled with increasingly low levels of physical activity, the excess energy is stored in the body as fat. In addition, there is likely a genetic component to obesity as highlighted by recent research: some people may have a genetic predisposition to becoming overweight or obese.[4] Still, obesity is a serious issue with dire consequences unless treated effectively.

Obesity is not unique to one sex, age group or ethnic group; however, it does affect certain groups more prominently than others. Some populations more vulnerable to obesity include low-income and minority communities and foreign immigrants to the United States.[5] Another vulnerable population of increasing public concern is children.

This thesis follows the style of the *Journal* of *Hunger and Environmental Nutrition.*

1.1 Childhood Obesity

Alarmingly, 31.7% of all children and adolescents in the United States aged 2 through 19 years currently meet the Centers for Disease Control (CDC) guidelines for being overweight or obese; 16.9% of these children have a body mass index (BMI) at or above the 95th percentile for their age and 11.9% are at or above the 97th percentile.[6] Influencing behavioral change early in obese children is exceedingly important as they possess an increased risk for developing type 2 diabetes, hypertension, and elevated lipid levels during their childhood. Children in this group are also at an increased risk of developing cancer and heart disease as adults.[7] Furthermore, if a child is obese at 6 years of age, he or she is 50% more likely to become an obese adult than non-obese children – carrying the consequences and risk factors associated with obesity into adulthood.[8] Childhood obesity is also strongly associated with increased rates of premature death in the United States population.[9]

Childhood obesity, like adult obesity, results from an energy imbalance in the body. However, while adults are consuming approximately 35% of their diets from solid fats and added sugars, the percentage is suspected to be 40% or higher for children.[10] In addition, it is estimated that 10-15% of children's total kilocalories come from sugar-sweetened beverages daily.[11] This is unsettling because children are constantly undergoing extensive growth and development; if a high percentage of their diet is composed of solid fats and added sugars (SoFAS), they may not be receiving sufficient nutrients for that growth and development.

Among children, some of the most vulnerable to obesity are those living in disadvantaged communities.[12]

1.2 Mexican-Origin Population along the Texas-Mexico Border

A disadvantaged population of increasing concern in the fight against childhood obesity is the Mexican-origin populace along the Texas-Mexico border. The obesity epidemic disproportionally effects minority ethnic groups like the Mexican-Americans.[13] In fact, Mexican-American boys have the highest rate of obesity among all child ethnic groups in the United States.[14-15] While a startling 43% of Mexican-American children 6-11 years old throughout the United States are overweight or obese [6], the rate is thought to be even higher along the Texas-Mexico border. Because of this, Mexican-American children at an increased risk of developing the co-morbidities associated with obesity. A recent study identified higher rates of obesity-related diabetes among Mexican-American children than any other ethnic group except for Native Americans.[13] Although much research is being conducted in this region; there is not much insight as to why obesity rates in children are higher along the border than in the rest of the United States.

The population along the Texas-Mexico border has risen considerably over the last few decades. In fact, this border area is growing at a rate almost twice that of the rest of the state of Texas: recent reports suggest a 35% population growth in Hidalgo County over the last decade as compared with an 18% growth for the State of Texas.[16] Immigrants from Mexico have crossed the border and set up communities known as *colonias* on inexpensive, already-present agricultural land. Families move in quickly and there are often hundreds of families living in the *colonia* before local officials even realize a *colonia* is developing.[17] *Colonias* have fairly low population densities and often lack adequate sewage systems and paved roads.[18] Many of the *colonia* homes are built by the residents themselves and frequently need repairs as they were built hastily and in an unregulated atmosphere. Few have air conditioning or even running water and many are infested with pests and rodents.

Residents of *colonias* are often first- or second-generation immigrants from Mexico and suffer from various health disparities including high rates of tuberculosis, a lack of ongoing healthcare, and a high exposure to particle matter negatively impacting health, among others.[19-20] These health disparities begin early in life and often persist throughout adulthood.[20] Furthermore, extended residency in the *colonias* is a proven predictor for lower physical health.[21] This is likely due to the innate hardships of immigration and assimilation into the United States.[22] The high rate of childhood obesity in *colonias* is another health disparity that should be added to the list for these communities.

Poston and Foreyt (1999) argue that obesity is an environmental issue.[23] They describe a "toxic environment" in which obesity is expected to occur if certain factors exist. This has also been called an "obesogenic environment" in the literature.[5] These factors are a high caloric diet, low levels of activity, low socioeconomic status and rural residence. All of these factors are present within the *colonia* environment. In order to determine why childhood obesity is so prevalent in South Texas *colonias,* it is necessary to look at features unique to the area. In particular, the conceptual model (see Figure 1) illustrates how the food environment and characteristics of the family and child influence food choice and dietary intake in children. Of great concern are the roles of the physical, cultural and economic aspects of the environment that provide barriers or facilitators to food choice.

Physical. The physical environment surrounding children in the *colonias* can either enhance or inhibit access to and the availability of healthy food options, which can directly affect whether or not a child consumes these foods. Components of this physical environment include not only the geographical location of the *colonias,* but also the framework of specific *colonia* neighborhoods, the physical structure of homes in these neighborhoods and the roads leading to and from the neighborhoods.

Neighborhoods in the *colonias* are, by nature, rural communities built on inexpensive patches of agricultural land in a close proximity to the Mexico border. In order for children to make healthy food choices, it is vital that they have access to healthy foods close to their homes. The rural nature of the *colonias* inhibits immediate access to limited healthy food selections. Rural areas like the *colonias* have been identified as "food deserts" in the literature.[24] Food stores selling healthy foods are less prevalent in rural *colonias* and residents must travel greater distances to access a full-service supermarket.[25] In addition, many *colonia* families lack access to a working vehicle, or have to pay someone for transportation.[26]

Often, the most opportune places available for purchasing food in the *colonias* are neighborhood convenience stores, fast food restaurants, *pulgas* (flea markets) and mobile food vendors traveling down the streets.[25, 27] A recent study highlights the fact that fresh fruits and vegetables are not readily available in these types of environments. To find healthy food items such as canned fruits and vegetables, whole-wheat bread and whole-grain cereal in rural communities like the *colonias*, residents have to travel to grocery stores or "dollar" stores.[28]

The limited access to and availability of healthy foods in *colonias* may lead to an increased consumption of more readily-available energy-dense, nutrient-poor foods and a higher risk of obesity.

Cultural. Cultural characteristics of the Mexican-American community also play a vital role in influencing children's food choice. Hispanic immigrants have been found to display a rapid acculturation of overweight behaviors upon entering the country including consuming an energy-dense, nutrient-poor diet, smoking and displaying inactivity.[29] This places Hispanic immigrants and their children at a higher risk of becoming overweight or obese.

Economic. The economic environment in the *colonias* provides another obstacle in children's food choices. In order for children to choose healthier foods, such options must be affordable to families. Income is limited among *colonia* residents; 57% of residents earn less than $11,600 per year. This is consistent with the known fact that Hispanic households have disproportionately low incomes.[30] In addition to having limited income, many *colonia* families report high levels of food insecurity.[26, 31] Children who live in both low-income and food insecure homes have been found to be more overweight than those in food secure homes.[32-33] In addition, these children consume higher amounts of cholesterol, eat less fruits and watch more television.[32] With such limited income and high rates of food insecurity, residents of the *colonias* strive to get the most out of each dollar they earn. Energy-dense, nutrient-poor foods are often more affordable than diets based on lean meats and fresh fruits and vegetables.[34]

1.3 Colonia Child Food Intake

The physical, cultural and economic characteristics of the *colonias* serve as both barriers and facilitators for healthy food options being available in the home. Food availability in the home has been directly linked to children's dietary intake in studies across the United States in food insecure homes: when money is limited and food available in the home is diminished, children's dietary intake suffers.[35-36]

In order to measure what foods are available for children to consume, researchers have traditionally utilized household food inventories (HFIs) along with 24-hour dietary recalls.[37] In a traditional HFI, amounts of all foods of caloric value in the child's home are inventoried and recorded. Various HFI tools have been developed and validated for use in dietary research.[38-39] The results of the HFI have been thought to be representative of what food the child is typically offered. Most HFI tools measure household food availability at one point in time; however, recent research suggests a multiple-occasion HFI may be more representative of the food available in the home.[40] Multiple-occasion HFI's can assess seasonal and monthly variations in the food supply at home that single HFI's would miss.

Utilizing an HFI to determine what foods are available for children to consume at home is undoubtedly beneficial; however, *colonia* households are unique in that many extended family members and numerous children often reside in the homes. Therefore, while various food items may be available in the home, they may not be accessible to *every* member of the household. In *colonias,* this factor would need to be accounted for to accurately determine what foods are available to the children. No studies to our knowledge have accounted for this in the *colonia* population.

Another limitation to the traditional HFI is that it does not account for the amount of total nutrients available for consumption in the home. However, no studies to our knowledge have examined the total nutrient values of foods represented in an HFI; only the amounts of the food items available are recorded. It would be beneficial to determine what *nutrients* are available to children in the *colonia* homes. Then, the relationship between the nutrients available in the home and the nutrients actually consumed by children via the 24-hour recall could be statistically analyzed for a correlation.

In order to prevent or reduce obesity among at-risk children, it will be necessary to understand household influences on food choice. Although researchers have suggested a link between certain foods, such as fruits or vegetables[41], that are available in the home and dietary intake, little is known about the influence of nutrients available in the home and dietary intake of children, especially Mexican-origin children. Thus, this study will use data from multiple 24-hour dietary recalls and HFI to assess the association between the presence of specific nutrients in the home and dietary intake of those nutrients among fifty Mexican-origin children (ages 6-11 years) in Texas border *colonias.*

2. METHODS

2.1 Conceptual Model

We adapt a conceptual model for the relationship between the household food environment and children's at-home food consumption (see Figure 1). This model suggests that children's food consumption is influenced to a large extent by household food supplies.

2.2 Study Design

Data come from Wave-1 (baseline) of a longitudinal cohort, which was designed to answer the overall research question: to what extent do household food availability and alternative retail food sources influence the dietary intake of Mexican-origin children 6-11 years who reside in *colonia* neighborhoods. This analysis will use cross-sectional data, which was collected February – April 2010, to examine the association of household food supplies on children's dietary intake. In this paper, we use data from baseline surveys, anthropometric measures, household food inventories, and 24-hour dietary recalls. The primary outcome measure is children's dietary intake.

2.3 Target Population and Communities

The target population is Mexican-origin families who reside in *colonias* in Hidalgo County, Texas. The study sample consisted of 50 family dyads (mother and child 6-11 years) from 40 *colonias* in 20 census block groups. Within the two areas, we indicate the proposed study of 20 census block groups (CBGs), and include 10 CBGs in western area and 10 CBGs in the eastern area. The western study area is 35.6 square miles, with a population of 35,021, up to 16.6% of households do not have a vehicle available, and 28%-69% of residents in CBGs have a household income below the poverty level. The 10-CBG eastern land area is 65.2 square miles, population of more than 32,500, up to 23.8% of households do not have a vehicle available, and 28%-58% of CBG residents have an income below the poverty level. In both areas, a majority of CBGs are considered highly deprived neighborhoods.[25]

2.4 Study Participants

Data, which were collected in Spanish, come from 50 participating dyads (mother and child 6-11 years) that were recruited by study *promotoras* (indigenous community health workers)*;* 25 from western area *colonias* and 25 from eastern area *colonias*. Letters of invitation were personally delivered by *promotoras*; explained to each household (e.g., inform about survey, confidentiality, financial incentive, etc.), and the first survey was scheduled within two days. The mother provided consent for herself and for her child to participate in the study; and the child provided assent to participate. All materials were reviewed by team *promotoras* and community partners to ensure semantic, conceptual, and normative equivalence, and cultural appropriateness; and necessary modifications were made. All protocols were approved by the Institutional Review Board at Texas A&M University.

2.5 Data Collection

Promotoras completed two full days of training on data collection and protection of participant confidentiality; all materials were pilot tested by trained *promotoras* in six households similar to study participants. All measures were translated into Spanish using translation-back translation method: 1) translation of the original English into Spanish, ensuring that the English meaning is maintained; 2) back-translation into English by an independent translator who is blinded and is not familiar with either the Spanish or English version; 3) comparison of the two English versions; and 4) resolve any discrepancies. *Promotoras* verified translation accuracy and appropriateness to ensure semantic, conceptual, and normative equivalence. Data for this study come from the child's survey, child's anthropometric measures, household food inventories, and 24-hour dietary recalls reported by the child.

Child Survey (CS). The children's survey was administered face-to-face and included demographics, transportation to school, grocery shopping, food program participation, food purchasing, and food security questions. *Demographics* included date of birth, grade in school, self-identified race/ethnicity, and nativity (country of birth). *Transportation to school* asked the method of transportation to school (e.g., school bus, parents drive, neighbor or relatives drives, ride a bicycle, walk, or other). *Grocery shopping* included their role in grocery shopping, favorite foods, and purchase of snacks. *Food program participation* included school breakfast program, school lunch program, and summer nutrition program. *Food purchasing* asked about types and purchase of snacks. *Food security* questions, using the last three months as the time frame, included nine questions and asked if each situation occurred "a lot," "sometimes," or "never."

Anthropometric measures. The anthropometric measure of body mass index (BMI) was used to gain a general picture of weight status. Weight was measured twice in the home with a portable, self-zeroing scale. Both measures were recorded; the average of the two was used for calculations. Standing height, in stocking feet, was determined with two measures using a portable stadiometer. Both measures were recorded; the average of the two height measures was used for calculations. BMI was calculated as weight (kg)/ height (m^2). Appropriate Centers for Disease Control and Prevention (CDC) growth charts and guidelines were used to determine gender and age-appropriate percentiles. Weight status categories were defined as underweight (less than the 5^{th} percentile), healthy weight (5^{th} percentile to less than 85^{th} percentile), overweight (85^{th} to less than 95^{th} percentile), and obese (equal or greater than the 95^{th} percentile).[42]

Household food inventories. Household food supplies were measured using a modification of the Household Food Inventory (HFI) previously used.[43] Two detailed inventories of all food and beverage items present and the amounts were conducted twice in each home, with a two-week interval. The HFI included the following categories: milk, dairy, ice cream, yogurt, and cheese; cereals; bread, cakes, crackers, and cookies; tortillas, pasta, and rice; chips and popcorn; legumes; fresh vegetables; canned vegetables; frozen vegetables; fresh fruit; canned fruit (heavy syrup, light syrup, or juice packed); frozen fruit; beverages; meat, poultry, ham, and sausage (fresh, frozen, or canned); seafood (fresh, frozen, or canned); oils and other fats; mayonnaise, sauce, and salad dressing; broth and soups; and miscellaneous food items (e.g., eggs, flour, nuts, peanut butter, candy, powdered chocolate or other flavors). Hard copy data were entered into Nutrient Data System for Research (NDS-R) 2009 for nutrient analyses. Two-time mean nutrient intakes, with equal weighting for each of the two HFI, were calculated for each child's household and used to determine the mean and median nutrient intakes for the entire sample.

Dietary recalls. Three 24-hour dietary recalls occurring on randomly selected, nonconsecutive days (one represents intake on the weekend and two for weekdays) were collected in the home, with the children as primary respondents. The first recall was collected during the first home visit, and the second and third recalls were collected in the home within two weeks of the first home visit. Detailed information on food and beverage consumption, including description, brand name, location of preparation, and method of preparation within the previous 24 hours were collected using standardized protocols following the multiple-pass interview technique of the Nutrition Data System for Research (NDS-R). Data were collected on hard copy, modified from an approach previously used by Dr. Sharkey;[44] and then entered into NDS-R. In the multiple-pass procedure, children were asked to provide a quick list of generic food items consumed; probes included food consumption occasions and locations, based on smaller chunks of time (e.g., before breakfast, breakfast, between breakfast and lunch and dinner). This was followed by a review of the quick list. During this pass, probes for forgotten foods were used; prompts for snacks, and the source of the food were asked. The third pass provided food details. This included time and place of the eating occasion, food descriptions, brand name, ingredients and preparation, and portion size and quantity eaten. The fourth pass was a final and comprehensive review of the previous day's intake. The face-to-face recalls in the home were used to establish rapport with the child and facilitate portion-size estimation. Several strategies were used to aid in the estimation of portion size. First, bowls, glasses, and cups that were usually used were measured and the information was recorded. Second, food models representing traditional Mexican foods and non-traditional foods were used. Third, three dimensional visuals were developed to better represent portions than customarily used two-dimensional portion models.[45] Nutrient calculations were performed with NDS-R 2009. Three-day mean nutrient intakes, with equal weighting for each of the three days (2 weekdays and 1 weekend) of dietary recall, were calculated for each child and used to determine the mean and median nutrient intakes for the entire sample.

2.6 Statistical Analysis

Data were analyzed with Stata statistical software release 11 (College Station, TX). Frequencies (categorical variables) and distribution (continuous variables) from the children's survey and anthropometric measures were calculated. Two-time means for nutrient availability from the HFI were calculated for each child's household. Nutrient intakes from the dietary recalls were assessed for weekend day, average of two weekdays, and three-day average for each child. Nutrient estimates were based exclusively on the consumption of foods and beverages; vitamin and mineral supplements did not contribute to the reported nutrient intakes. Although NDS-R output provided estimates for 161 nutrient types, eight nutrients were selected based on the nutritional needs of children 6-11 years old. The nutrients of interest for this analysis were total energy (kcal), % calories from fat, total protein (g), total dietary fiber (g), calcium (mg), sodium (mg), total sugar (g), and added sugar (g). Means, standard deviation, and medians were calculated for each of the nutrients. The mean and median for the weekday (WDA) and weekend (WEA) dietary intakes were compared using the t-test to compare the mean; and the paired Wilcoxon test or the paired-sign tests to compare the medians. The purpose of the comparison was to determine if the children's dietary intake on weekdays differed from weekend days.

The Household Food Inventory (HFI) data were collected on two occasions. Mean, standard deviation, and median were calculated for the same eight nutrients as the dietary recalls. The correlation between the dietary data and the HFI data were determined in order to identify the possible relationship between the two. In order to configure the correlation between the dietary data and the HFI data, the raw HFI data should be modified into the equivalent portion of the nutrient needed by each sample child, because the amounts of nutrients measured in the HFI are for the whole household rather than for the child alone. For instance, if the family of 3 adults and 2 children reported the HFI to be 1000, it will be absurd to argue that the 1000 HFI was distributed to one child or the equal portion of 200 HFI was distributed to the each member of the household disregarding any personal characteristic of individual (e.g., age and gender) that may contribute to the food consumption. The idea of reflecting the allocated proportion of food to an individual household member in the total HFI is similar to the idea of the adult equivalent scale (AES) used in econometrics to reflect the consumption behavior of an individual household member in the total household expenditure. The AES allocates different weights to household members depending on a number of characteristics that may determine the responsive variable of interest. There are many different approaches to calculate AES;[46-47] and several different types of AES exist and they could be continuous, discrete, or both.[46] In econometrics, the AES is commonly used in the study of food expenditures and the household composition, and the Tedford-Capps-Havlicek model (TCH model) has become the one of the most popular approaches for the application.[46, 48-50] Because of characteristics of the data and small sample size, a modified TCH model was estimated. After calculating the household adult equivalents, the HFI was weighted with the appropriate adult equivalent. Correlation between the HFI and the children's dietary intake was determined by calculating the correlation coefficients and also by using scatter plots.

Using backward elimination of all variables with $p > 0.05$, multivariable linear regression models were estimated for dietary intake of each nutrient.

3. RESULTS

Characteristics of the 50 Mexican-origin children (ages 6-11 years) are shown in Table 1. Almost one-third of children reported that they were born in Mexico. On the average, participant children lived in households with 5.7 adults and children (range 3-10). The number of adults in a household ranged from 1-4; the number of children ranged from 3-10. None of the children rode a bicycle to school; 78% traveled to school on a school bus. All children participated in school breakfast and lunch programs. Age- and gender-specific body mass index (BMI) percentiles indicated that 48% of children were considered to have a healthy weight, while 42% were considered overweight or obese.

Children's food security status based on the children's responses that each of nine situations occurred "a lot" or "sometimes" in the last three months is shown in Table 2. A greater percentage of children reported meals with cheap foods (54%), worrying that food would run out (46%), and running out of food (40%). After summing the responses (range 0-9), 18% (*n* =9) were food secure (reported never to all nine questions); 18% were marginally food secure (reported a lot or sometimes to one question); 36% (*n* = 18) were considered to have low food security (reported a lot or sometimes to 2-4 questions); and 28% (*n* = 14) were considered to have very low food security (reported a lot or sometimes to 5 or more questions).

Table 3 reports mean, standard deviation (SD), median, and range for 3-day average dietary intake for total energy (kcal), total protein (g), total dietary fiber (g), calcium (mg), sodium (mg), percent of calories from fat, total sugar (g), and added sugar (g). Table 4 compares the mean and median weekday and weekend dietary intake. Calcium intake was significantly lower on weekends compared with weekdays; and percent of calories from fat was significantly greater on weekends compared with weekdays.

Mean, median, and range of nutrients, based on the average of two household food inventories, for the entire household and child' equivalent portion are shown in Table 5. The distributions and medians differed between unadjusted and adjusted values ($p < 0.001$). Correlations among nutrients from the dietary recalls are shown in Table 6. All nutrients were significantly correlated with total calories; the largest correlations were for total protein, total sugar, sodium, and added sugar. Correlations between the adjusted household inventories and dietary intake are reported in Table 7. Sodium was the only nutrient with a significant correlation between household availability and children's dietary intake. In data not shown on unadjusted associations with dietary intake, nativity (born in Mexico) was associated with lower sodium intake; underweight was associated with lower percentage of calories from fat; and lower food security was associated with increased intake of energy (total calories), total sugar, and added sugar. None of the other characteristics were significantly associated with dietary intake.

Table 8 shows the results from multivariable linear regression models for dietary intake. Lower food security was associated with greater energy, total sugar, and added sugar intakes. Household food inventory was independently associated with greater intake of sodium and lower intakes of total sugar and added sugar.

4. DISCUSSION

This study extends our understanding of the relationship between what is available in the home and what children eat. Examining the dietary intake among children is one of the first steps in combating childhood obesity across the United States. It is well acknowledged that what is available in the home for children to eat influences what they eat.[51-55] Studies that have recognized this influence have utilized a variety of measures to assess the diets of children including household food inventories (HFIs)[56-57]; however, the household food inventories utilized have several recognized shortcomings.

First, most HFIs were measured at one point in time.[52, 57-64] Recent studies have found that a one-time measurement of household food supplies is inadequate when compared with multiple assessments over a period of time, especially in low-income families.[40, 65] The one-time measurement fails to account for monthly and seasonal food supply changes when hardships make frequent food purchases necessary. Second, many HFIs only capture what is present in the home, either by individual foods or food groups; they do not account for quantities of the food present.[56-57, 64, 66-67] These studies assume that if there is at least one of a certain kind of food present (e.g. fruits, vegetables, or high-fat foods), this type of food is available to members of the household. Additionally, traditional HFIs only analyze whole foods, but do not look at food available in the home at the nutrient level. Finally, studies utilizing HFIs have not considered the importance of accounting for household composition when determining what foods are available in the home. Adjusting for household composition would likely present a more accurate picture of what food is available to specific members of the family.

In this study, we kept these limitations in mind when constructing the research design and our analysis ended up with several key findings. One was that the extent of food insecurity among children of the *colonias* was alarming. Our findings show that when food security status is controlled for, food security itself is related to energy, total sugar and added sugar intake. More specifically, the greater the food insecurity, the more total energy, total sugar and added sugar was consumed. This is in line with the literature as it is widely recognized that energy-dense, nutrient-poor foods are often more affordable.[34, 68-72] If the family has a limited income, they tend to purchase and consume more energy-dense foods for a fear of running out of food in the home. This has a profound effect on the weight status of low-income children.[33, 73]

Another key finding involved analyzing children's diets using the Nutrition Data System for Research (NDS-R) software. After entering the data from the 3 24-hour dietary recalls from the children, we were presented with values of approximately 160 nutrients in the data output. We focused on 8 specific nutrients that have an impact on growing children: total energy (kilocalories), total protein, total dietary fiber, calcium, sodium, percentage of kilocalories from fat, total sugar and added sugar. With these 8 nutrients, we found a difference in the children's weekend day versus weekday intake of calcium and percentage of calories from fat: while calcium intake was significantly lower on weekends, the percent of calories from fat intake was significantly higher on weekends. This could be due to the fact that all of the children in the study participated in school nutrition programs; therefore, most of these children were provided with breakfast and lunch at school Monday through Friday. The composition of school lunches is tightly regulated: milk consumption is encouraged with every meal and the fat content is controlled. The children's nutritional environment was likely not as regulated on the weekend days as it was during the weekdays.

A third finding of this study indicates an associated between HFIs and children's intake of sodium and total sugar. To determine this, we not only analyzed children's dietary intake in NDS-R; but, also entered all of the recorded items from the HFI into the program and received output at the nutrient level. No prior studies to our knowledge have looked at household food availability at the nutrient level. We found a positive association between the amount of sodium in the home and the children's intake of sodium; conversely, we found an inverse relationship between the amount of total sugar (any foods containing any of the six mono- and disaccharides: glucose, fructose, galactose, sucrose, lactose and maltose) available in the home and total sugar consumed by children. Interestingly, the amount of added sugar available in the home was also inversely associated with children's intake of added sugar (sugars added to foods during preparation or commercial food processing); but, this finding was slightly out of the statistically significant range. These results could indicate that the children are not eating sugars and added sugars at home: they may be consuming them at food establishments outside the home such as convenience stores, mobile food vendors, flea markets, or others. However, determining where the children were accessing these nutrients was outside the scope of this study.

This study has both methodological and substantive strengths. Methodologically, this study incorporates many novel approaches in obtaining household food profiles and children's dietary intake. It is one of the few studies to utilize 3 24-hour dietary recalls on children to obtain an accurate representation of their typical intake. Also, when obtaining these 24-hour recalls, trained researchers used a multi-modal approach for estimating portion size, presenting a more accurate picture of the children's previous day intake. In addition, we collected 2 HFIs for each household to obtain a more typical nutrient profile for the home. Substantively, this study looks at a vulnerable, hard-to-reach population along the South Texas border that is typically difficult to study. Therefore, these results might be similar to those we might find in other hard-to-reach populations.

However, as with any study, there are limitations to our findings that should be addressed in any further studies examining the association between household food availability and children's dietary intake. First, the sample size is relatively small with only 50 children participating, which limits the ability to generalize our findings with the entire South Texas *colonia* population. Second, although multiple HFIs were conducted for each household, none of these accounted for seasonal variability in the food supply. All HFIs were conducted in a 3-month time period between February and April 2010. Therefore, there might be a seasonality bias to our results. Regardless of these limitations, we cannot overlook the significance of our findings as they shape the direction for future research with this population and with other low-income hard-to-reach populations across the United States. Future studies should look at the relationship between household food availability and children's dietary intake over a longer period of time and with a larger sample to determine the ability to generalize our findings across the entire South Texas *colonia* population.

5. CONCLUSION

This study shows a relationship between household food availability and children's dietary intake. However, at the nutrient level, this association is only statistically significant for sodium and almost significant for total sugar. *Colonia* children are likely eating many meals outside of the home; thus, the traditional HFI might not be useful in determining what foods are available for these children to eat.

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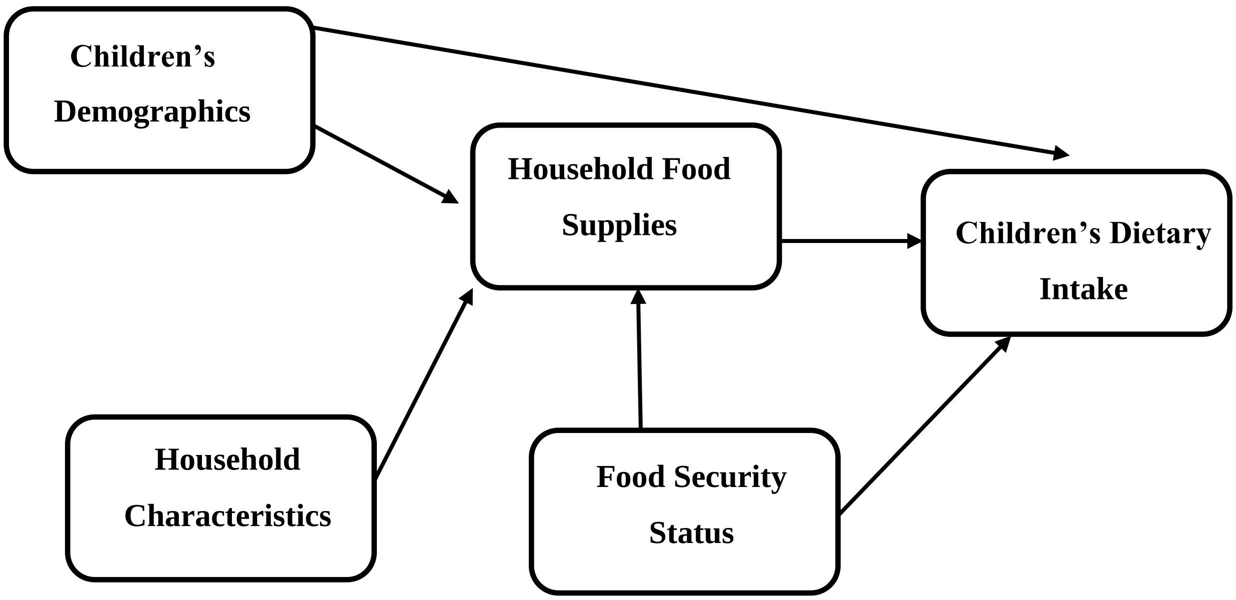
APPENDIX A

FIGURE

Figure 1. Conceptual Model



APPENDIX B

TABLES

TABLE 1. CHARACTERISTICS OF MEXICAN-ORIGIN CHILDREN (*N* = 50)

Demographic characteristics	Mean ± SD	% (*n*)
Gender		
Girls		62% (31)
Age, years	9.1±1.3	
Grade in school		
1-2		46% (23)
3-4		40% (20)
5-6		14% (7)
Race/ethnicity		
Hispanic		46% (23)
Mexican		26% (13)
Mexican American		28% (14)
Country of birth		
Mexico		32% (16)
Household composition		
Number of adults	2.2±0.8	
Number of children	3.5±1.2	
Total adults and children	5.7±1.5	
Transportation to school		
School bus		78% (39)
Parent drive		20% (10)
Walk		8% (4)
Ride bicycle		0% (0)

TABLE 1. CONTINUED

School nutrition programs	Mean ± SD	% (*n*)
Breakfast		100% (50)
Lunch		100% (50)
Summer		36% (18)
BMI Percentile Category		
Underweight		10% (5)
Healthy weight		48% (24)
Overweight		18% (9)
Obese		24% (12)

TABLE 2. CHILDREN FOOD SECURITY (*N* = 50)

In the last 3 months,	% (*n*)[1]
1. Did you worry that food at home would run out before your family got money to buy more?	50% (25)
2. Did the food that your family bought run out and your family did not have money to get more?	46% (23)
3. Were you not able to eat a variety of healthy foods at a meal because your family didn't have enough money?	40% (20)
4. Did your meals only include a few kinds of cheap foods because your family was running out of money to buy food?	54% (27)
5. Was the size of your meals cut because your family didn't have enough money for food?	34% (17)
6. Did you have to eat less because your family didn't have enough money to buy food?	32% (16)
7. Did you have to skip a meal because your family didn't have enough money for food?	30% (15)
8. Were you hungry but didn't eat because your family didn't have enough food?	8% (4)
9. Did you not eat for a whole day because your family didn't have enough money for food?	12% (6)
Food Security Categories	
Food secure	18% (9)
Marginal food security	18% (9)
Low food security	36% (18)
Very low food security	28% (14)

TABLE 3. SUMMARY OF CHILDREN'S DIETARY INTAKE, BASED ON 3-DAY AVERAGE

	Mean (SD)	Median	Range
Total energy (kcal)	2034.87 (372.76)	2027.82	1244.89 – 2888.15
Total protein (g)	82.87 (19.73)	82.51	41.62 – 135.12
Total dietary fiber (g)	15.18 (5.05)	14.38	8.19 – 32.86
Calcium (mg)	993.41 (300.46)	975.72	438.16 – 1696.67
Sodium (mg)	3450.67 (913.18)	3423.16	1857.12 – 5738.44
% Calories from Fat	34.00 (4.08)	34.10	24.90 – 41.33
Total sugar (g)	130.27 (35.52)	124.28	66.43 – 229.53
Added sugar (g)	77.42 (33.82)	73.00	19.47 – 170.83

TABLE 4. COMPARISON OF MEAN AND MEDIAN WEEDKAY AND WEEKEND DIETARY INTAKE FOR 50 CHILDREN

	Weekday	Weekend Day
Total energy (kcal)	2008.11±375.78 (2028.92)	2097.47±717.65 (2058.57)
Total protein (g)	81.10±19.95 (80.66)	86.45±36.68 (85.38)
Total dietary fiber (g)	15.52±5.30 (15.28)	14.57±9.76 (11.23)
Calcium (mg)	1056.34±299.62 (1014.96)	898.24±566.23** (738.00)
Sodium (mg)	3372.06±994.77 (3333.76)	3553.50±1694.97 (3093.88)
% Calories from Fat	32.55±4.23 (31.60)	36.83±7.85** (36.88)
Total sugar (g)	132.80±39.75 (128.27)	127.70±56.68 (116.62)
Added sugars (g)	75.21±36.87 (72.40)	83.02±50.82 (74.15)

Statistically significant difference in means and medians (in parenthesis): * $p < 0.05$ ** $p < 0.01$

TABLE 5. SUMMARY OF HOUSEHOLD FOOD AVAILABILITY[1]

	Entire Household			Child's Equivalent Portion[2]		
	Mean (SD)	Median	Range	Mean (SD)	Median	Range
Total energy (kcal)	119899 (37677.7)	117319.8	49719.4 – 215159.6	25661.9 (15108.9)	24951.2	8744.8 – 87571.7
Total protein (g)	3363.4 (1180.7)	31814.7	1487.6 – 6738.3	818.7 (516.4)	699.2	261.6 – 3124.3
Total dietary fiber (g)	981.2 (354.9)	943.7	227.6 – 1720.4	251.1 (190.3)	195.8	40.04 – 1071.2
Calcium (mg)	20516.9 (7057.4)	20531.7	7521.7 – 41495.6	5030.7 (3136.9)	4007.2	1322.9 – 15593.7
Sodium (mg)	110220.5 (40885.3)	106262.4	32153.5 – 239768.1	27241.3 (18120.7)	23405.2	5801.1 – 116195
% Calories from Fat	50.5 (9.1)	52.2	29.6 – 68.3	12.4 (6.5)	11.1	4.2 – 39.9
Total sugar (g)	2920.9 (1288.2)	2766.5	606.3 – 6592.8	697.3 (390.7)	609.3	106.6 – 2109.6
Added sugar (g)	2133.8 (1240.3)	1692.4	383.5 – 6007.4	496.4 (290.7)	414.3	67.5 – 1349.1

[1] Based on average of two household food inventories
[2] Modified Blokland approach to allocate a proportion of in the household to participant child

TABLE 6. CORRELATION OF SELECT NUTRIENTS FROM DIETARY RECALLS[1,2]

	Total Energy (kcal)	Total Protein (g)	Total Dietary Fiber (g)	Calcium (mg)	Sodium (mg)	Calories Fat (%)	Total Sugar (g)	Added Sugar (g)
Total Energy (kcal)								
Total Protein (g)	0.789 (0.000)							
Total Dietary Fiber (g)	0.415 (0.003)	0.387 (0.005)						
Calcium (mg)	0.563 (0.000)	0.380 (0.006)	0.111 (0.442)					
Sodium (mg)	0.647 (0.000)	0.655 (0.000)	0.501 (0.000)	0.378 (0.007)				
Calories Fat (%)	0.282 (0.047)	0.326 (0.021)	-0.016 (0.915)	-0.037 (0.802)	0.364 (0.009)			
Total Sugar (g)	0.660 (0.000)	0.265 (0.063)	0.025 (0.862)	0.472 (0.000)	0.166 (0.248)	-0.197 (0.171)		
Added Sugar (g)	0.581 (0.000)	0.196 (0.173)	-0.165 (0.251)	0.359 (0.011)	0.181 (0.209)	-0.011 (0.938)	0.872 (0.000)	

[1] Correlation (*P*-value)
[2] Average of 3 24-hour dietary recalls

TABLE 7. CORRELATION BETWEEN CHILD'S DIETARY INTAKE[1] AND HOUSEHOLD FOOD INVENTORY[2] (*n* = 50)

	Total Energy (kcal)	Total Protein (g)	Total Dietary Fiber (g)	Calcium (mg)	Sodium (mg)	Calories Fat (%)	Total Sugar (g)	Added Sugar (g)
Correlation	0.215	0.246	0.182	0.107	0.352	0.204	-0.230	-0.220
p-value	0.134	0.085	0.205	0.460	0.012	0.156	0.109	0.125

[1]Intake based on average of three 24-hour dietary recalls
[2]Based on average of two household food inventories, adjusted for household composition

TABLE 8. COEFFICIENT ESTIMATES FROM MULTIPLE VARIABLE LINEAR REGRESSION MODELS FOR ASSOCIATION OF FOOD SECURITY AND HOUSEHOLD FOOD INVENTORIES WITH DIETARY INTAKE (*n* = 50)

	Energy β (SE)	Protein β (SE)	Dietary fiber β (SE)	Calcium β (SE)	Sodium β (SE)	Fat β (SE)	Total sugar β (SE)	Added sugar β (SE)
Food security[1]	46.55*	1.01	-0.33	21.39	14.78	0.21	6.23***	5.89***
	(20.5)	(1.1)	(0.29)	(17.31)	(50.5)	(0.23)	(1.76)	(1.68)
Household food inventory[2]	0.003	0.008	0.006	0.006	0.017*	0.105	-0.026*	-0.029[a]
	(0.003)	(0.006)	(0.004)	(0.014)	(0.007)	(0.093)	(0.012)	(0.015)
R^2	0.195	0.076	0.06	0.043	0.125	0.057	0.251	0.246

[1] Number of food security questions with a response of “a lot” or “sometimes”. Greater number indicates lower food security.
[2] Average of two household food inventories adjusted for household composition using the modified Blokland approach.
Statistical significance: [a]p <0.06 * p <0.05 ** p <0.01 *** p <0.001

VITA

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