Food Security and Nutritional Health of School-Aged Children in Two Caribbean Countries

by

Walaa A. Mumena

McGill University, Montreal

June 2016

A thesis submitted to McGill University in partial fulfillment of the requirement of the degree of

Doctorate of Philosophy

TABLE OF CONTENTS

ABSTRACT

Background: Food insecurity has been linked to children's diet, health and growth, but the link is less clear in upper-income developing countries, including those in the Caribbean. This study aims to investigate the association between food insecurity and nutritional health among school-aged children in two Caribbean countries for which there is a dearth of recent nutritional data. The growing problem of obesity was also addressed as well as anemia as a potential marker of dietary insufficiency.

Methods: A longitudinal study was conducted of 390 children aged 6-10 years at baseline, recruited from eight schools in Trinidad and seven schools in St. Kitts, and their caregivers, in 2012-14. Demographic variables, food insecurity (measured by USDA's food security standardized questionnaires), one 24-hour dietary intake of children, anthropometric measures for children and caregivers, and children's hemoglobin level (measured by by HemoCue) were measured at two time points.

Results: The prevalence of household food insecurity at the household level was 42%, while food insecurity at the child level was 27%. Household food insecurity was linked to lower intakes of protein and zinc. There was no association between food insecurity and any anthropometric measures. The incidence of becoming overweight (8.8%) or obese (8.1%) over 18 months was high and very few children (1.6%) moved from being overweight or obese to a healthier (lower) weight group. In regards to diet, a lower intake of fruit was reported among children who become overweight or obese as compared to those who remain in the same weight category. These was a lack of association between energy intake and children's weight status; however, under-reporting of energy intake was evident among overweight and obese children as compared to children who were not. Predictors of increasing adiposity over an 18 months period were older age, higher baseline BMI z-score and HFA z-score. The prevalence of anemia among children was 30%. Dietary intake of children was not linked to anemia. Food insecurity and being of African origin were associated with lower hemoglobin levels.

C**onclusion**: Food insecurity is marginally associated with diet, but not with any growth indicators in the Caribbean settings studied. It is, however, associated with anemia. Given the rapid increase in the prevalence of overweight and obesity as well as the continuing problem of anemia, more attention to diet quality and nutrient adequacy are needed. Improving children's dietary intake at an early age is important in an attempt to limit the rapid increase in the prevalence of obesity and to address anemia, which may be due to nutrient deficiency.

RÉSUMÉ

L'insécurité alimentaire a été liée au régime alimentaire des enfants, à la santé et à la croissance, mais le lien est moins clair dans les pays en voie de développement à revenu élevé. Cette étude tente de trouver le lien entre les indicateurs de la sécurité alimentaire et la santé nutritionnelle chez les enfants en âge scolaire dans deux pays des Caraïbes pour lesquels il y a un manque de données récentes en ce qui concerne la nutrition. Le problème croissant de l'obésité ainsi que l'anémie ont été abordés comme des éléments potentiels de l'insuffisance al imentaire. Une étude longitudinale a été menée sur 390 enfants âgés de 6 à 10 ans et de leurs aidants , les enfants ont été recrutés dans huit écoles au Trinidad et dans sept écoles à St. Kitts en 2012-2014. Les variables démographiques, la situation de la sécurité alimentaire (mesurée par le questionnaire normalisé relatif à la sécurité alimentaire de l'USDA), un apport alimentaire de 24-heures pour enfant, des mesures anthropométriques pour les enfants et les soignants, et le niveau de l'hémoglobine chez les enfants (mesuré avec un HemoCue) ont été relevés deux fois. La prévalence de l'insécurité alimentaire au niveau des ménages a été de 42% alors que l'insécurité alimentaire chez les enfants a été de 27%. L'incidence en surpoids 8.8% ou en obésité 8.1% sur 18 mois était très élevée et très peu d'enfants (1.6%) sont passés de l'état de surpoids ou d'obésité à un état de poids santé. La prévalence de l'anémie chez les enfants était de 30%. L'insécurité alimentaire est liée à des apports en protéine et en zinc plus faibles. Il n'y a aucun lien entre la sécurité alimentaire et toute mesure anthropométrique. L'apport alimentaire chez les enfants n'est pas lié à une augmentation de l'adiposité ou du niveau de l'hémoglobine. Les prédicteurs de l'augmentation de l'adiposité sur une période de 18 mois étaient plus âgés, les résultats du niveau de IMC et de HFA plus élevés. L'insécurité alimentaire et être d'origine africaine étaient liés à des niveaux d'hémoglobine plus faibles. L'insécurité alimentaire est un peu liée au régime alimentaire, mais pas aux indicateurs de croissance dans l'environnement des Caraïbes étudié.

Elle a, cependant, un lien avec l'anémie. Vu la croissance rapide dans la prévalence du surpoids et de l'obésité en plus du problème de l'anémie, plus d'attention à la qualité des régimes alimentaires et des aliments doit être accordée. Améliorer les apports alimentaires chez les enfants à un jeune âge est très important pour limiter l'augmentation rapide dans la prévalence de l'obésité et remédier à l'anémie qui peut être due à une défaillance nutritive.

ACKNOWLEDGMENTS

I would first like to express my gratitude to my supervisor Dr. Katherine Gray-Donald for helping me grow professionally and for the insights she provided throughout this process. She was not only my supervisor; she was a caring friend. Special thanks to my committee members, Dr. Sonia Laszlo and Dr. Isabella Granderson, for their guidance as I completed my thesis. Without their expertise and suggestions my work would not be the same. Thanks to Mrs. Louise Johnson-Down whose advice and efforts were also appreciated. Thanks to Dr. Leroy Phillip for his leadership in the CARICOM Food Security Project and for his contribution in providing input in my work. I also would like to thank Dr. Hugo Melgar-Quiñonez for his help in validating the food security measure used in this study.

I would further like to express my deepest appreciation to my friend Dr. Khalid Aba-Alkhail for his help and continued support throughout this process. I would also like to deeply thank my family, especially my mother for her love and emotional support throughout my life, as well as my children, Abdullah, Juoana and Aljoud, without those I love I would not be the person I am today. This work is also dedicated to the memory of my father.

PREFACE AND CONTRIBUTION OF AUTHORS

In this thesis, prevalence data for food insecurity, obesity and anemia were determined among school-aged children aged 6-10 years at baseline from Trinidad and Tobago and St. Kitts and Nevis. Chapter 1 provides the rationale for the study and outlines the objectives of the doctoral research. Chapter 2 presents an in-depth literature review concerning food insecurity and children's diet, growth, obesity and anemia. The findings of the research are presented in the form of three manuscripts in Chapters 3 to 6. Chapter 3 investigates the prevalence of food insecurity and its relation to the nutritional health of school-aged children in two Caribbean countries, Trinidad and Tobago and St. Kitts and Nevis, who participated in the nutrition component of "From Farm to Fork," a food security project in the CARICOM region. Chapter 4 examines the incidence of overweight and obesity and predictors of adiposity change in school-aged children in the Caribbean. The WHO cut-offs were used to identify children's weight categories and Cole et al.'s method was used to measure changes in adiposity. In this chapter, misreporting for energy intake was assessed and adjusted for in the regression analysis using Goldberg cut-offs. Chapter 5 reports on the prevalence of anemia and its correlates among school-aged children. The prevalence of anemia was estimated using race-specific cut-offs for children of African origin. Additional analyses are provided in Chapter 6, which covers baseline household food security and wealth status in relation to children's nutritional health. This thesis ends with a summary of findings and an overall conclusion in Chapter 7.

This doctoral dissertation is original regarding both objectives and findings. The candidate was responsible for data management and analyses as well as preparation of all manuscripts. Dr. Katherine Gray-Donald, the thesis supervisor, worked with the candidate on the formulation of the research objectives. Dr. Gray-Donald was consulted about data interpretation and made editorial revisions of manuscripts.

This is the first study to obtain a comprehensive data set of food security and nutritional health from a relatively large sample of children from two Caribbean countries. The diversity of variables included in the data set offered a unique opportunity to explore food security, diet, growth, obesity and anemia status.

This thesis has made significant contributions to the understanding of food insecurity and nutritional health of school-aged children in Caribbean countries. Recent data are not available regarding food security, growth and obesity and there is no evidence regarding dietary practices or anemia in this age group. The results of this study will help to understand the relationship of food insecurity and nutritional indicators and help to prioritize the development of nutrition interventions to prevent obesity and anemia.

LIST OF TABLES

LIST OF FIGURES

CHAPTER I. INTRODUCTION

The Caribbean Community and Common Market (CARICOM) consists of 15 developing countries.[1] These countries vary in size and level of development, but as a group, they are identified by the Food and Agriculture Organization (FAO) as experiencing food insecurity (Dell'Aquila, Ford, & Conforti, 2007; FAO, 2010). Food insecurity is considered to be a significant challenge in the CARICOM countries, because a number of countries in the region are highly dependent on imported foods (Dell'Aquila, Ford, & Conforti, 2007, 2007; FAO, 2010; Lovendal, Jakobsen, & Jacque, 2007). However, most countries in the CARICOM region are identified by the World Bank as either high-income or upper middle-income countries, with the exception of a few countries (World Bank, 2015).[2]

Food insecurity is a complex problem that is linked to poor nutritional outcomes (Black, Allen, Bhutta, Caulfield, de Onis, Ezzati, Mathers, & Rivera, 2008; WHO, 2015). Despite limited data regarding food insecurity and the nutritional health of Caribbean children, the increased prevalence of obesity and the under-nutrition problem have drawn attention to the impact of food insecurity on children's dietary intake and nutritional status in Caribbean countries (Lovendal, Jakobsen, & Jacque, 2007; WHO & FAO, 2002).

In 2011, the International Development Research Center (IDRC) in Canada funded the CARICOM food security project, "From Farm to Fork." This initiative aimed to improve the nutrition and health outcomes of CARICOM populations through agricultural interventions linked to nutrition in schools (IDRC, 2011). The supervisor for this thesis, Dr. Katherine Gray-Donald, was involved in the nutrition intervention of this project. In September 2011, the

---

[1] CARICOM countries are Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, Suriname and Trinidad and Tobago.

[2] Haiti and Guyana are low-income countries, and Montserrat is categorized as other.

doctoral candidate started to study food insecurity in relation to the nutritional health of Caribbean children living in two countries, Trinidad and Tobago, and St. Kitts and Nevis, for her doctoral research.

1.1. Rationale

This study is an epidemiological study of diet, obesity and anemia. While food insecurity, diet, obesity and anemia have been extensively investigated in developed countries, few studies have been conducted in developing countries. This study could be used as a benchmark for Caribbean countries and other upper-income developing countries by providing researchers with information regarding food insecurity and children's current dietary intakes and nutritional health. The findings of this study will advance the knowledge of health professionals and policy makers who are working on nutrition interventions in upper-income developing countries, including Caribbean countries.

1.2. Objectives

1. To examine the link between food insecurity in relation to dietary intake and the nutritional status of school-aged children in two Caribbean countries.

2. To determine the incidence of overweight and obesity as well as predictors of increased adiposity among school-aged children in two Caribbean countries over a period of 18 months.

3. To estimate the prevalence of anemia among school-aged children in two Caribbean countries and to investigate its correlates, including dietary intake, iron, and its protein source (animal vs. plant).

1.3. References

Black, R. E., Allen, L., Bhutta, Z. A., Caulfield, L. E., de Onis, M., Ezzati, M., . . . Rivera, J. (2008). Maternal and child undernutrition: global and regional exposures and health consequences. *The Lancet, 371*(9608), 243-260.

Dell'Aquila, C., Ford, D., & Conforti, P. (2007). *Agricultural trade policy and food security in the Caribbean : structural issues, multilateral negotiations and competitiveness*. Rome: Trade and Markets Division.

FAO. (2010). *Challenges and outlook for the Caribbean subregion*. Retrieved Nov 29th, 2015, from: http://www.fao.org/docrep/meeting/018/k7679E.pdf

FAO. (2015). *Regional overview of food insecurity Latin America and the Caribbean*. Retrieved Nov 11th, 2015, from: http://reliefweb.int/sites/reliefweb.int/files/resources/Regional Overview of Food Insecurity Latin America and the Caribbean.pdf

IDRC. (2011). From farm to fork: improving nutrition in the Caribbean. *Canadian International Food Security Research Fund.* Retrieved Oct 30th, 2015, from: http://www.idrc.ca/EN/AboutUs/Donor_Partnerships/Canadian_International_Food_Security_Research_Fund/Pages/106525.aspx

Lovendal, C. R., Jakobsen, K. T., & Jacque, A. (2007). *Food prices and food security in Trinidad and Tobago*. Rome. Retrieved Nov 11th, 2015, from: http://www.fao.org/3/a-ai134e.pdf

WHO. (2015). *Food security, trade, foreign policy, diplomacy and health.* Retrieved Aug 20th, 2015, from: http://www.who.int/trade/glossary/story028/en/

World Bank. (2015). Country and lending groups. Retrieved Nov 19th, 2015, from: http://data.worldbank.org/about/country-and-lending-groups - High_income

CHAPTER II. LITERATURE REVIEW

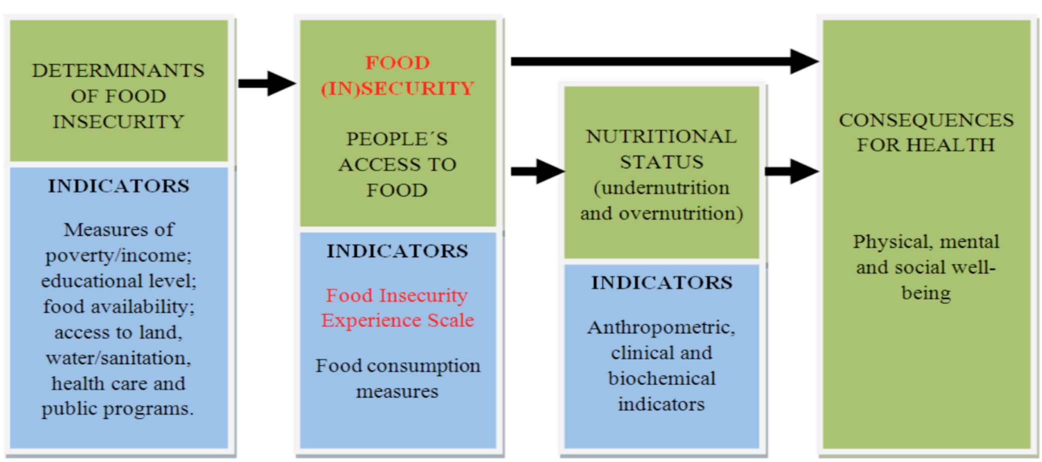
This literature review provides an introduction to the food insecurity, dietary intake and nutritional status of children in the Caribbean. It covers major topics related to the assessment, prevalence and correlates of food insecurity, dietary intake, obesity and anemia. The review focuses on studies conducted among school-aged children, although a number of studies referenced in this review were not conducted in the Caribbean due to the limited data available in this region.

2.1. Food Insecurity

2.1.1. Concept and Prevalence of Food Insecurity

The World Food Summit (1996) defined food security as existing "when all people at all times have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active, healthy life" (FAO, 1996). Food insecurity is a complex issue linked to health, as food insecure individuals are at higher risk of undernourishment (Black, Allen, Bhutta, Caulfield, de Onis, Ezzati, Mathers, & Rivera, 2008; WHO, 2015a). Determinants and consequences of food insecurity are summarized in **Figure 1.**

Figure 1: Determinants and consequences of food insecurity at the individual level



Source: (FAO, 2013)

In developed countries, smaller proportions of the population are experiencing food insecurity as compared to populations living in developing countries. In Canada in 2012, 8% of households were experiencing food insecurity (Statistics Canada, 2015), and in the U.S. in 2013, 14% of households were food insecure (USDA, 2015). In developing countries, data regarding the prevalence of food insecurity at the national level were lacking. However, there are data available at the regional level in developing countries. In a study conducted in 2011 among the rural population of the Kilosa district in Tanzania, household food insecurity was reported to be as high as 80% (Ntwenya, Kinabo, Msuya, Mamiro, & Majili, 2015). A cross-sectional study conducted in the Philippines, Bolivia and Burkina Faso between 2003-04, which included 300 households from rural and urban areas in each country, reported that 35%, 70% and 73% of households, respectively, were food insecure (Melgar-Quinonez, Zubieta, MkNelly, Nteziyaremye, Gerardo, & Dunford, 2006). In the Caribbean, the prevalence of food insecurity is not well documented, although a number of reports have been written on the topic. A report by the Food and Agriculture Organization (FAO) showed a drop in the prevalence of chronic undernourishment in the Caribbean, which was calculated using the number of individuals who do not meet their energy requirement, which droped from 27% in 1990-92 to 20% in 2014-16 (FAO, 2015; FAO & WFP, 2015). The prevalence of undernourishment was calculated based on the FAO method that is described in detail on page 8. There are virtually no data describing food insecurity directly and none describing trends over time. One study reported on the prevalence of food insecurity in the Caribbean, but the study reported only on adult and child food insecurity (not at the household level). The sample (n=3,858) was recruited from Trinidad and Tobago and the study was conducted to validate the use of the 18-item Household Food Security Module of the USDA, which is an experience-based food insecurity measurement scale. This questionnaire of the USDA has been widely used to measure food security in a number of settings internationally because it provides information regarding the severty of food insecurity at the adult and child levels as well as at the household level. More detailed information about experience-based food insecurity measurement scales is provided on pages 9-15. At the adult level, an estimate of 19% experienced food insecurity without hunger, 10% experienced food insecurity with moderate hunger and 6% experienced food insecurity with severe hunger. At the child level, an estimated 23% experienced food insecurity without hunger and 9% experienced food insecurity with hunger (Gulliford, Nunes, & Rocke, 2006). An earlier study conducted by Gulliford and colleagues aimed to validate the use of the six-item short form of the USDA module with a sample of 531 subjects from 286 households in the North-central area of Trinidad. This study found that 25% of households were experiencing food insecurity (Gulliford, Mahabir, & Rocke, 2004).

Food security involves four dimensions: food availability, accessibility, utilization and stability. Food availability is achieved at the national level when adequate food is available for the population's use, while at the household level, food availability is affected by food production, purchases and donations. Food accessibility refers to economic and physical access to food. Food utilization is based on sanitation and feeding practices, food preparation, diet diversity and the distribution of food within the household. Food stability refers to the presence of these three dimensions over time (Gross, Schoeneberger, Pfeifer, & Preuss, 2000).

Food insecurity is a concern in the Caribbean, as a number of countries in the region are highly reliant on imported foods. In 2006, Trinidad and Tobago imported 12% of its supply of fruit, 50% of its vegetables, and almost all of its milk, while St. Kitts and Nevis imported 34% of its supply of fruit, 69% of its vegetables, and 82% of its milk (FAO, 2007). In the Caribbean in

2000-02, energy, protein, fat and sweetener availability rose above the recommended population goals, while the availability of fruit, vegetables and staples, though increasing, remained below the recommended population goals in many Caribbean countries, as shown in **Table 1** (CFNI & FAO, 2007).

Table 1. Food availability in the CARIFORUM countries [1]

Food Availability	**Availability[1] (Calories/caput/day)**		**RPG[2]**	**2000-02 Surplus (+) or Deficit (-) relative to RPG (%)**
	1991-03	**2000-02**		
Total Food Calories	2,933	3,071	2,250	36(+)
Carbohydrates	1,766	1,825	1,238	47(+)
Protein	313	336	225	49(+)
Fats/Oils	746	802	450	78(+)
Fruits/Vegetables	215	238	337	29(-)
Sweeteners	393	424	180	136(+)
Staples[3]	967	974	1012	4(-)

[1]Calories/caput/day; [2]Recommended Population Goal; [3]Staples=Cereals + Starchy Roots
Source: FAOSTAT. www.fao.org. August 2006.

A number of countries in the CARICOM region are vulnerable to food price increases due to a high reliance on imported foods (Dell'Aquila, Ford, & Conforti, 2007). In developing countries, evidence has suggested that there is a relationship between food prices and dietary intake (Abdulai & Aubert, 2004; Handa & King, 2003; Lovendal, Jakobsen, & Jacque, 2007). Increased food prices may also affect the food intake of individuals from food insecure households. It has been noted that price increases for inelastic basic food items, including cereals, result in a larger share of household income being spent on these irreplaceable items. The researchers found that increases in maize and rice prices in Tanzania resulted in decreased energy intake (Abdulai & Aubert, 2004). This study demonstrated an association between income and energy intake. However, a Trinidadian study found no association between income

[1] CARIFORUM countries are CARICOM countries and the Dominican Republic

and energy intake. This study suggested that purchasing inelastic food items at higher prices might replace the purchase of more elastic foods, such as fresh meats, fruits and vegetables. Households will purchase high-energy inelastic foods in order to maintain an adequate energy intake (Lovendal, Jakobsen, & Jacque, 2007).

2.1.2. Methods for Measuring Food Insecurity

To assess food insecurity, five methods (both direct and indirect approaches) are noted in the literature. Advantages and disadvantages of all five methods are provided in **Table 2.**

1) The FAO method. This method is based on food availability data. It uses an estimate of energy per capita at the national level. Data are obtained from household income and expenditure surveys (for data regarding variability in energy intake) and Food Balance Sheets. This method requires information about the total energy availability in a specific year, the population size, the coefficient of variation of energy intake to generate the distribution curve of energy intake, and the cut-off point that is required to estimate the proportion of the population that falls below the minimum per capita average energy requirement (FAO, 2002; Pérez-Escamilla & Segall-Correa, 2008).

2) Household income and expenditure surveys. These surveys are used to assess poverty. This method uses an estimate of energy consumed per household member per day. It requires information about the amount of money spent on food and other necessities during a specific time period. These surveys collect essential information regarding the quantity of food purchased and total cost of food consumed inside or outside the house, as well as the quantity of food grown at home for consumption, and all food received by any means (FAO, 2002; Pérez-Escamilla & Segall-Correa, 2008).

3) Individual's dietary intake. This method assesses the impact of food insecurity on the individuals' dietary intake. Dietary intake is measured by a number of methods, including 24-hour dietary recall, food frequency questionnaires and food records. Cut-off points are used to determine the proportion of the sample at risk of nutrient deficiencies (FAO, 2002; Pérez-Escamilla & Segall-Correa, 2008). Detailed information regarding the assessment of dietary intake is provided on pages 19-22.

4) Anthropometry. Anthropometric indicators (height-for-age, weight-for-age and weight-for-height are mainly used among children) assess the impact of food insecurity on the individuals' nutritional status (FAO, 2002; Pérez-Escamilla & Segall-Correa, 2008). Anthropometric measures and classifications are described in detail on pages 22-28.

5) Experience-based food insecurity measurement scales. This method is the only direct or fundamental measure of food insecurity. The U.S. Household Food Security Survey Measure (HFSSM), also called the 18-item U.S. Household Food Security Survey Module of the USDA, is based on this method. This measurement scale was created and documented by Radimer et al. from Cornell University in the 1980s using qualitative methods to better understand the experience of food insecurity among low-income women living in upstate New York. That study investigated women who expressed uncertainty and anxiety in relation to their inability to obtain sufficient quantities of food. In the 1990s, the 18-item HFSSM was developed by the USDA based on the Cornell/Radimer scale, which has 15 items and 3 sub-items, but major changes were made in 2005 to the algorithm in order to classify households into different severity levels of food insecurity (Nord, Andrews, & Carlson, 2005). The Cornell/Radimer scale measures the severity of food insecurity, which includes assessments of food anxiety at the household level and food quality and quantity at the household, adult and child levels (Radimer, Olson, Greene, Campbell, & Habicht, 1992; Radimer, Oslon, & Campell, 1990). The HFSSM is an effective tool for measuring food insecurity, as it provides information regarding the severity of food insecurity, such as “low food security” or “very low food security,” at various levels (household, adult and child) (Cafiero, Melgar-Quiñonez, Ballard, & Kepple, 2014; USDA, 2012). Furthermore, this measure has been validated in a number of settings, including Caribbean settings (Gulliford, Nunes, & Rocke, 2006). In addition, the HFSSM has been shown to be a stable, robust, and reliable measurement (Bickel, Nord, Price, Hamilton, & Cook, 2000). A detailed guideline of this measure provided in **Appendix A** (USDA, 2012)**.**

The HFSSM has been used annually in the U.S. to assess food insecurity through the National Health and Nutrition Survey (NHANES). Also, researchers have adapted and validated the HFSSM to be used in other settings (Bickel, Nord, Price, Hamilton, & Cook, 2000). The HFSSM is also used in the Canadian Community Health Survey (CCHS) (Statistics Canada, 2015). Although the HFSSM is used both in Canada and in the U.S., there are two key differences between the Canadian and the U.S. versions. One is that the Canadian version uses two scales with separate scores to measure food insecurity at the adult and child levels, while in the U.S. version a single scale is used to measure food insecurity at the household level. Another difference is related to scoring. In the U.S. version, three or more affirmative responses are necessary to indicate food insecurity, whereas in Canada only two or more affirmative responses are needed. Due to different cut-off points, the U.S. version of the HFSSM might exclude food insecure households with less obvious signs, although this does not apply to households with children (Nord & Hopwood, 2008).

Other food insecurity measures were used in different settings, such as the Household Food Insecurity Access Scale (Ntwenya, Kinabo, Msuya, Mamiro, & Majili, 2015), which was developed by the Food and Nutrition Technical Assistance (FANTA) project team, and the Latin American and Caribbean Household Food Security Measurement Scale (Pérez-Escamilla, Melgar-Quiñonez, Nord, Alvarez Uribe, & Segall-Correa, 2007).

Table 2. Derived and fundamental food insecurity measures

Method	Principles	Advantages	Disadvantages
Derived measures			
FAO method	- Outcome: national calories available *per capita* per day - Inputs: food balance sheets, energy intake coefficient of variation, single cut-off point to estimate at-risk population	- Inexpensive - Applied worldwide on annual basis	- Does not identify at-risk households or individuals - Dietary quality not taken into account - High measurement error - Low standardization on data collection methods across countries - Evidence-base of cut-off point is questionable
Household expenditure surveys	- Outcomes: caloric intake *per capita* per household, dietary variety score - Inputs: money spent on food and other needs, foods consumed and market value, reference time period, food composition tables to convert food expenditures and consumption into energy intake	- Identifies vulnerable households - Can take into account dietary quality - Used for evaluating national anti-poverty and assistance programs	- Measures food available but not necessarily consumed during period of interest (periodicity bias) - Difficult to estimate foods consumed outside the household, fed to animals, exchanged as gifts or payment of work - Difficult to standardize methodology across countries - Expensive and logistically difficult - Data usually not available annually
Dietary intake	- Outcomes: Individual's food group intake counts, nutrient intake - Inputs: 24-hour recalls, FFQ, food records, food composition tables, known nutrient requirements, reference time period	- Measures actual food consumption - Can assess short medium and long term food intake - Deals with both dietary quality and quantity - Identifies at-risk households and individuals	- Memory "recall" bias - High intra-subject variability in food and nutrient intakes - Difficult to assess portion sizes - Food composition tables need to be of high quality and culturally appropriate - Uncertainty about human requirements for most nutrients - High cost especially for inclusion of 24-hour recalls in national surveys - National data unavailable annually
Anthropometry	- Outcome: % population malnourished - Inputs: weight height, other body dimensions	- Highly standardized - Evidence-based cut-off points - Inexpensive - Frequently applied in national surveys	- Nutritional status indicator - FI-obesity relationship difficult to interpret
Fundamental measure			
Experience-based food insecurity scales	- Outcome: Household level of food insecurityInputs: scale containing items representing the conceptual and multidimensional nature of FI, algorithm to convert scale scores into FI categories	- Fundamental measure of FI - HFSSM and adaptations valid across diverse socio-cultural settings - Captures the physical and psycho-emotional dimensions of FI - Low cost allowing for decentralization	- Does not capture food safety dimension - Different reference time periods and frequency response options needed in different settings - Difficult to standardize cut-off points across regions/countries -"Benefit" bias

FFQ: food frequency questionnaire; FI: food insecurity; HFSSM: US Household Food Security Survey Measure; FAO: Food and Agriculture Organization.

Source: (Pérez-Escamilla & Segall-Correa, 2008)

Validity and reliability of experience-based food insecurity measurement scales:

Experience-based food insecurity measures should be validated and their reliability assessed in each setting before use. Validity refers to how accurately a measure represents the concept it claims to measure (Punch, 1998). Measurement of validity is often used to assess measurements of subjective and abstract phenomena, e.g. food insecurity. Thus, qualitative and quantitative constructs were created by social scientists to address the validity of their measurements. Types of validity include construct validity [2], content validity [3], face validity [4] and criterion-related validity [5] (Hulley, Cummings, Browner, & Grady, 2013). Measuring criterion-related validity is the strongest approach for a number of measures used in clinical and epidemiological studies (Roberts, 2006). In the context of validating a food security measure, criterion validity is not used, due to the absence of pre-existing validated measures of food insecurity. An internal validity (Rasch model) is used instead.

The basic concept of validating an experience-based food security measure involves simply assessing item severity (items comprising these measures vary in terms of the severity of food insecurity that they indicate) and household severity (overall patterns of the household response to items are used to assess the exact severity of food insecurity). The Rasch model (or One Parameter Logistic Model), a psychometric test, is used to examine the internal validity of household food security surveys in a targeted population. This method is useful to validate experience-based food security measures, as it formalizes the concept of the severity-ordering of items and provides a standard statistical approach to estimate the severity of every item in each

[2] Construct validity is the degree to which a specific measuring device agrees with theoretical construct.
[3] Content validity examines how well the measurement represents all aspects of the phenomena of interest.
[4] Face validity describes whether the measurement seems inherently reasonable.
[5] Criterion-related validity is the degree to which a new measurement correlates with well accepted existing measure.

household. Also, this method assesses the consistency of the patterns of observed responses with the concept of severity ordering (Nord, 2014).

The Rasch model provides three estimates, where the first is the item severity level. Second is the item-fit statistics (item-infit and item-outfit), which indicates how well responses to items compare to Rasch model assumptions. The item-infit statistics are examined to assess if all items measured the same condition of interest (food insecurity) with nearly equal discrimination. The item-outfit statistics are based on squared errors; thus, they are sensitive to highly unconvincing responses (outlier sensitive), making them less useful than the item in-fit statistics in validation. Expected values for both statistics (infit and outfit) are equal to 1.0. Item-fit statistics compare the deviations expected under Rasch assumptions with the observed deviations of responses. Values over 1.0 indicate that items are less strongly related to food insecurity as measured by the set of items (poorer fit), while values below 1.0 indicate that items are more strongly related to food insecurity than the average item. Best infits are below 0.7 and very good infits are between 0.8 and 1.2, while an infit between 0.7 and 1.3 is considered to be usable (but not for general use). The third estimate is the differential item functioning (DIF), originally called item bias, which assesses the invariance of the response patterns between less/more acculturated households (Kilanowski & Lin, 2012; Nord, 2014).

Reliability refers to the degree of reproducibility. To assess the reliability of a food security measure, one does not use test-retest reliability, as food insecurity is not a static condition (Tarasuk, 2002). Cronbach's alpha coefficient procedure is commonly used to evaluate the reliability of a specific food security measure. Cronbach's alpha estimates the average of all split-half estimates of reliability. A split-half test is performed by randomly splitting all the responses into two sets of question, totalling the scores of the two sets, and then working out the correlation between them. A more advanced approach for using this test, as compared to splitting the questions into two sets, is to create all possible split halves and determine the average correlation between all of them (Roberts, 2006).

2.1.3. Food and Nutrition Security

There has been a global shift from severe under-nutrition, where individuals struggle to maintain an adequate energy intake, to a less severe form of under-nutrition in which individuals have sufficient energy intakes, but their energy comes mainly from an unbalanced diet, such as diets that are high in added sugar and fat (WHO & FAO, 2002). This pattern is often referred to as “Western” diet (Cordain et al., 2005; Feferbaum, de Abreu, & Leone, 2012; USDA, 2010). In response to this global shift, the FAO has promoted the use of the term “food and nutrition security” instead of “food security and nutrition” to distinguish between food quantity (energy) and quality (dietary diversity) and to underline this difference (FAO, 2004). Food insecurity affects children differently than adults (Kirkpatrick & Tarasuk, 2008). In fact, mothers often protect their children from food insecurity, including severe food insecurity, as the mothers ensure that the children have enough food to eat (Campbell & Desjardins, 1989; Radimer, Olson, Greene, Campbell, & Habicht, 1992; Nord & Hopwood, 2008; Tarasuk & Maclean, 1990; Travers, 1996).

Regarding food insecurity and diet quality in Canada and the U.S., food insecurity has been linked to dietary inadequacy and poor diet quality (i.e. low intake of calcium, vitamin D, fruits and vegetables) (Kendall, Olson, & Frongillo, 1996; Kirkpatrick & Tarasuk, 2008; Mark, Lambert, O'Loughlin, & Gray-Donald, 2012). A study conducted by Kirkpatrick and Tarasuk (2008) investigated the relationship between food insecurity at the household, adult and child levels, and dietary adequacy of Canadians ages 1-70 years. Among adults, food insecurity was associated with a higher proportion of energy coming from carbohydrates, and fewer servings of fruits, vegetables and milk on average compared to the food secure group after controlling for income, education, immigrant status, smoking status and household size. The prevalence of inadequacy of a number of nutrients, including protein, zinc and B_{12}, was higher among adolescents and adults in food insecure households. Among children, whose food insecurity was measured specifically at the child level, however, there were few differences in dietary intakes between food secure and food insecure groups. However, food insecure children in some age groups consumed fewer servings of milk, fruits and vegetables. Among the food insecure children aged 9-18 years, a higher prevalence of inadequacy of protein, vitamin A, magnesium, phosphorus, and zinc was observed, as compared to the children in the food secure group (Kirkpatrick & Tarasuk, 2008).

Using data from the CCHS and NHANES during two 2-year cycles covering 2003–06, a recent study compared the dietary inadequacy among youth and adults living in food insecure households in Canada compared to the U.S. It was found that, despite the higher prevalence of household food insecurity in the U.S., the dietary inadequacy for calcium and milk were higher among food insecure households in Canada. This study concluded that household food insecurity is a stronger marker for dietary vulnerability in Canada than in the U.S. (Kirkpatrick, Dodd, Parsons, Ng, Garriguet, & Tarasuk, 2015).

In less privileged countries, food insecurity is associated with low dietary diversity. A study of children aged 5-8 years from Ethiopia, India, Peru, and Vietnam examined the relationship between household food security status and children's dietary diversity. The findings showed that children in food insecure households had significantly less diverse diets than children in food secure households, specifically regarding animal-source foods, such as meat, eggs, and dairy products (Humphries et al., 2015; Ntwenya, Kinabo, Msuya, Mamiro, & Majili, 2015). Also, in rural Tanzania, household food insecurity was associated with less dietary diversity, using the 9-item Household Food Insecurity Access Scale (Ntwenya, Kinabo, Msuya, Mamiro, & Majili, 2015).

The relationship between food insecurity and dietary intake indicates that, in most settings, individuals from food insecure households have a less varied or nutritionally inferior diet compared to individuals from food secure households. Most studies on this topic were conducted in Canada and the U.S.; thus, the link between food insecurity and children's dietary intake in upper-income developing countries, including most Caribbean countries, is not clear.

2.1.4. Food Insecurity and Nutritional Health

Nutritional status has been used to measure food insecurity indirectly (FAO, 2013; Pérez-Escamilla & Segall-Correa, 2008) However, studies examining the relationship between food insecurity and children's growth have shown inconsistent findings. The relationship between food insecurity and under-nutrition varies by setting. In countries where under-nutrition is highly prevalent, food insecurity is reflected in reductions in growth. In contrast, the relationship is not present in countries with a low prevalence of under-nutrition. For example, in Columbia and Tanzania, where stunting and underweight are prevalent (stunting prevalence in Columbia and Tanzania are 13% and 42%, respectively (UNICEF, 2013b, 2013c), food insecurity is associated with higher rates of stunting and underweight among children and adolescence (Cordeiro, Wilde, Semu, & Levinson, 2012; Hackett, Melgar-Quinonez, & Alvarez, 2009; Isanaka, Mora-Plazas, Lopez-Arana, Baylin, & Villamor, 2007), while in countries with low rates of stunting and underweight such as Brazil (stunting rate in Brazil is 7% (UNICEF, 2013a)), no such association was found (Cordeiro, Monego, & Martins, 2014). A longitudinal study of children aged 5-8 years from Ethiopia, India, Peru, and Vietnam examined the relationship between household food insecurity and children's anthropometric measures. They found that children living in food insecure households had lower HFA z-scores compared to children living in food secure households (Humphries et al., 2015). While no association of food insecurity and HFA is seen in countries with higher standards of living, there is a clear association of food insecurity and stunting in less privileged settings.

Research concerning the relationship between food insecurity and obesity in developing countries is limited. In a study conducted among women and children in Brazil, household food insecurity (assessed using the Brazilian Food Insecurity Scale) was not linked to obesity among preschool-aged children (Schlüssel, Silva, Pérez-Escamilla, & Kac, 2013). In the U.S., a number of studies reported no association between food insecurity at the household level and obesity among children (Bhargava, Jolliffe, & Howard, 2008; Bhattacharya, Currie, & Haider, 2004; Eisenmann, Gundersen, Lohman, Garasky, & Stewart, 2011), although other American studies have found evidence of an association between food insecurity and obesity or higher BMI (Jyoti, Frongillo, & Jones, 2005; Metallinos-Katsaras, Must, & Gorman, 2012). However, the latter two studies are limited, as one study included a small sample of children (n=124) in the fifth grade from a Hispanic community, and the other study recruited preschool children from exclusively low-income communities. This conclusion of no relationship between food insecurity and obesity among children in developed countries was also supported by the American Dietetics Association (ADA) statement made in 2003, which declared "household food insecurity does not appear to be associated with overweight among children". The ADA recommends using a comprehensive food security measure at the child level to investigate the association between food insecurity and obesity among children (ADA, 2003).

Regarding the relationship between food insecurity and anemia, a limited number of studies have been conducted in developing and developed countries. These studies found that, in both settings, food insecurity was associated with higher prevalence of anemia among young children. In rural India, household food insecurity was associated with anemia among toddlers aged 12-23 months (n=401) (Pasricha et al., 2010). In the U.S., a cross-sectional study among children ages ≤ 36 months (n=626) who were using the emergency department services, reported an association between food insecurity and iron deficiency anemia, but not anemia without iron deficiency or iron deficiency without anemia (Skalicky et al., 2006). However, in a study conducted among children aged 3-19 years (n=11,247) using the NHANES 1999-2004, the findings were inconsistent (based on age group). Using the child-specific measure of food security, this study found a significant positive association between food insecurity and iron deficiency anemia, only among children aged 12-15 years (the model was adjusted for sex, race and other variables), but this relationship was not evident when examining food insecurity at the household level (Eicher-Miller, Mason, Weaver, McCabe, & Boushey, 2009).

2.2. Assessment of Diet, Weight and Growth

2.2.1. Measures of Diet

Measuring diet is challenging and different methods are used, but all suffer a number of constraints. The aim is always to measure the usual intake of individuals but this is difficult and costly. The 24-hour dietary recall and diet records are commonly used measures and they are based on the actual food consumed by an individual for a minimum of one day. The required number of days to obtain a good estimate of usual intake is calculated based on the within-person variability of the nutrient of interest, which varies widely by nutrient.

Using data for a single day's dietary intake is not possible to estimate dietary adequacy for individuals, as a failure to account for the within-person variability. At a group level, using one dietary recall will result in an overestimation of the prevalence of inadequacy. However, it has been suggested that with a single 24-hour dietary recall available for each subject, it is possible to adjust the reported intake distribution using an external estimate of within-person variation (Institute of Medicine, 2000). A study conducted by Jahns et al. found that the use of external within-person variance estimates gave a more accurate depiction of dietary inadequacy than non-adjusted intake distributions (Jahns, Arab, Carriquiry, & Popkin, 2004). To estimate the prevalence of dietary inadequacy, there are two available methods: the probability method that applies a continuous risk-probability function to the estimated intake of each individual, then averages the probabilities of the individual across the population; the Estimated Average Requirement (EAR) cut-point method that compares dietary intake data for individuals with information on the distribution of the requirements (Institute of Medicine, 2000).

The recalls and records methods are both short-term, expensive methods and they require more effort and time to collect data over multiple days. Because of these limitations, it is mostly used in relatively small studies where specific descriptions of foods and preparation methods are needed or in national surveys where there is a subsample with a second recall to estimate within-person variability and the aim is to have exact food quantities (Willett, 2012).

A systematic review was conducted to compare the validity of a number of dietary assessment methods, including multiple 24-hour dietary recalls for children, to the gold standard measure for assessing energy expenditure, which is the doubly-labeled water (DLW) method. This method assumes that children are in energy balance, which means energy intake equals energy expenditure. This review concluded that for children aged 4-11 years, multiple 24-hour recalls (for a minimum of three days, including weekdays and weekend days) was the most accurate method for estimating total energy intake when completed with the assistance of parents (Burrows, Martin, & Collins, 2010).

Regardless of the measure used to assess diet of children, it is recommended to ask the child to work with the caregiver to report dietary intake in order to increase the validity of the reported intake. A study has shown that "collaborative" recalls have higher degree of validity in reporting energy intake, as compared to recalls completed independently by the child or the caregiver (Eck, Klesges, & Hanson, 1989). This is particularly important for children aged 9 years and younger (Baranowski et al., 2012). Also, using pictures of foods to help young children report portion sizes increased data accuracy (Baranowski et al., 2011).

Misreporting of dietary intake. Under-reporting of energy intake is a problem among young children, as well as among obese individuals (Murakami, Miyake, Sasaki, Tanaka, & Arakawa, 2012; Poppitt, Swann, Black, & Prentice, 1998; Subar et al., 2003). One study found that under-reporting is significantly higher among overweight and obese individuals as compared to their non-obese counterparts, and this under-reporting led to the masking of the association between energy intake and overweight/obesity among children aged 2-9 years (n=5,357). This study also found that, adjusting for misreporting in multivariate analysis resulted in a change in the results, whereby it was found that fruit and vegetable intake (as a percentage from the total energy intake) was lower among overweight/obese children (Börnhorst et al., 2013). Under-reporting of energy intake among adults was associated with high intake of added sugars, while among children under-reporting of energy intake was associated with high protein intake and low intake of simple carbohydrates (Lioret et al., 2011; Sichert-Hellert, Kersting, & Schöch, 1998)

Since misreporting has been identified as a problem in relation to assessing dietary intake, a number of approaches have been developed to identify misreporting. In the 1990s, Goldberg and colleagues introduced a relatively uncomplicated approach to identify misreporting, which used the ratio of reported energy intake (REI) relative to total energy expenditure (TEE) (physical activity level × basal metabolic rate). However, this approach originally required a measure of physical activity (PA) level to calculate the TEE, which was lacking in most studies. In response, a number of researchers used Goldberg's approach with an estimated PA factor of 1.55 × BMR (light PA) to adjust for misreporting of energy intake in studies conducted among children and adults with single day dietary data (Brion et al., 2010; Johnson, Mander, Jones, Emmett, & Jebb, 2007; Murakami, Miyake, Sasaki, Tanaka, & Arakawa, 2012; Timpson et al., 2008).

Dietary intakes can be identified based on Goldberg cut-offs as under-reports, plausible reports or over-reports of energy intake. Classification is based on the individual's ratio of REI to TEE. In most studies, cut-offs depend on whether the ratio is within, below, or above the 95% confidence limits for the expected ratio of 1.0 (agreement of REI and TEE as measured by the DLW method proposed by Black and Cole) (Black & Cole, 2000). Using this approach, under-reports are defined as having a ratio of <0.76, plausible-reports have ratios between 0.76 and 1.24, and the ratio for over-reports is >1.24 (Black, 2000).

2.2.2. Measures of Growth

Anthropometric measurements are used to calculate indices of growth. The most commonly used indices in research population in children are height-for-age, weight-for-height, weight-for-age, BMI and weight change.

1) Height-for-age (HFA). This is a measure of the linear growth achieved. Low HFA (cut-off point of < −2 SD) (WHO, 2015b) reflects stunting or the failure to achieve the appropriate height relative to age. Stunting is a result of inadequate food intake for long periods, poor dietary intake, poor sanitation and hygiene, or combination of some or all of these factors. It is commonly found in low-income settings. In settings with a high prevalence of low HFA, stunting due to environmental conditions is the most likely explanation for why children have a low height measurement; in settings with a low prevalence of stunting, genetic factors are a more likely explanation for children with low HFA. The distribution of HFA for a population is usually symmetrical, so the mean is very close to the median (Gibson, 2005; WHO, 1995).

2) Weight-for-height (WFH). This is a measure of body weight relative to height. Low WFH (cut-off point of < −2 SD) (WHO, 2015b) reflects wasting, which suggests a failure to gain sufficient weight relative to height or a loss of weight. High WFH reflects overweight or obesity, which indicates excess weight gain relative to height. The WFH is a useful measure for children aged 1 to 10 when no information regarding exact date of birth is available, as WFH is independent of age for this age group. It is important to understand that WFH does not distinguish between a very tall child who is thin and a very small child who is thin. The distribution of WFH for a population is usually skewed, so the mean and the median are dissimilar and standard deviations above or below the median are unequal as well (Gibson, 2005; WHO, 1995).

3) Weight-for-age (WFA). This is a measure of body mass relative to age. Low WFA (cut-off point of < −2 SD) (WHO, 2015b) reflects underweight. Also, this measure could be used to assess overweight and obesity. The problem with WFA is that it reflects WFH and HFA; thus, it cannot distinguish between tall and thin children as opposed to children who are short and heavy.

Thus, WFA is not recommended to be used alone, as it will overestimate the prevalence of underweight among children who are short for genetic reasons. As the distribution of WFA for a population is usually skewed, the mean and the median are dissimilar and standard deviations above or below the median are unequal as well (Gibson, 2005; WHO, 1995).

4) Body Mass Index (BMI). This is a widely used measure of body composition (calculated as weight/height^2) that is recommended for use with both children and adults. The recommendation is based on the strong positive correlations between BMI and total body fat (Ranasinghe et al., 2013; Widhalm, Schönegger, Huemer, & Auterith, 2001). There are significantly stronger correlations between childhood BMI and young adulthood BMI, as compared to correlations of skinfold measures at these two respective age groups. Also, there are a link between BMI among children and adolescents and major risk factors of a number of chronic diseases, including adverse lipoprotein profile, increased blood pressure and late onset diabetes (Dwyer & Blizzard, 1996; Zwiauer, Widhalm, & Kerbl, 1990). Despite the correlation between BMI and body adiposity, assessed by Dual X-ray Absorptiometry (DEXA), BMI is not a perfect indicator of body fatness, as it may misclassify some children of normal fatness to be overweight or some overweight children to be within the healthy weight range. Other factors, such as large head size or enhanced muscular development, may falsely classify some children to be overweight when they are not. Among children, sex and age are important factors of the assessment of overweight and obesity using BMI, as they play an important role in children's body composition. Thus, transformation of BMI to a percentile or z-score adjusted for age and sex is important in measuring children's weight status.

Percentiles and z-scores in anthropometric measures have been widely used to help assess growth and nutritional status. The percentile refers to the position of an individual on a given reference distribution. A percentile also determines the expected percentage of the population that is above or below the particular value chosen, with a ceiling of the 99th percentile. One drawback of the percentile is that for different measurements, the same interval of percentile values do not correspond to the same ranges of absolute values. In contrast, z-scores indicate the distance and direction of the measure which deviates from the population mean as expressed in SD units. The distribution of z-scores have a mean of zero and a SD of one. Z-scores also have the challenge of having somewhat of a ceiling effect as the growth curve data at extreme values are not the true SD.

5) Weight changes. With the recent increases in obesity, changes in children's weight are important to assess. In cross-sectional applications, either BMI z-score or BMI percentile can be used to determine cut-offs and classify weight status of children and adolescents (Must & Anderson, 2006). However, when assessing change in adiposity, changes in BMI percentile represent very different amounts of absolute weight gain depending on the relative weight of the child. Limited research is available to identify the optimal measure to assess weight change among growing children. Although changes in BMI and BMI z-score have been used to assess increases in adiposity (Hughes, Sherriff, Lawlor, Ness, & Reilly, 2011; Jyoti, Frongillo, & Jones, 2005; Klesges, Klesges, Eck, & Shelton, 1995; Scharf & DeBoer, 2015), it is not recommended to use changes in BMI z-score to measure weight change (Cole, Faith, Pietrobelli, & Heo, 2005).

Cole and colleagues conducted a study that aimed to identify the optimal BMI measure for adiposity change of growing children. The study included 135 Italian children aged 29–68 months at baseline. Change in adiposity over time was measured by change in BMI, the change in BMI%, or the change in BMI z-score or percentile. BMI z-scores and percentile for age and sex were derived from the United States Centers for Disease Control and Prevention (CDC) 2000 reference. All four measures were sex and age adjusted measures of adiposity. Cole at al. adjusted BMI for age by subtracting the age–sex-specific median BMI, and BMI % was similarly defined as 100 $\log_e$ (BMI/median BMI), which is the percentage difference from median BMI. This study found strong correlations between all four measures ($r > 0.9$), particularly between change in BMI and change in BMI%. It was concluded that BMI and BMI% are better to assess adiposity change in growing children, and that BMI z-score is only optimal to assess adiposity cross-sectionally (Cole, Faith, Pietrobelli, & Heo, 2005). The change in BMI was also identified as the best measure of adiposity change among children in a more recent study conducted among 557 Canadian children aged 8-10 years. This study compared change in BMI (as a raw score), change BMI% (adjusted), change in BMI percentile and change in BMI z-score (using CDC standards). Fat mass (using DEXA) was strongly correlated with change in BMI ($r = 0.86$), while change BMI percentile had the lowest correlation among all measures used (Kakinami, Henderson, Chiolero, Cole, & Paradis, 2014).

BMI Classifications. There are three main reference standards that are frequently used to assess obesity (Gonzalez-Casanova et al., 2013).

1) The International Obesity Task Force (IOTF). This system was developed by a group of IOTF experts in 2005. Researchers used the adult BMI cut-off points for overweight above 25 kg/m^2 and obesity above 30 kg/m^2 and modeled the data on children from six countries (U.S., U.K., Hong Kong, the Netherlands, Singapore and Brazil), so that the cut-point for overweight would be the curve which met a BMI of 25 kg/m^2 once they reached adulthood (Cole, Bellizzi, Flegal, & Dietz, 2000).

2) The United States Centers for Disease Control and Prevention (CDC) criteria. Growth charts issued in 2000 were an update of the National Center for Health Statistics (NCHS)

1977 growth reference that used data from five American surveys between 1963 and 1994 (Kuczmarsk et al., 2002). The CDC defines overweight as a BMI above the 85^{th} percentile and below the 95^{th} percentile of the reference population and obesity as a BMI above the 95^{th} percentile.

3) The WHO criteria. This system was developed by a World Health Organization (WHO) expert committee in 2007 using the 1977 CDC's National Center for Health Statistics (NCHS) growth reference of children aged 5-19 years, supplemented with data from the WHO Child Growth Standards for children aged 0-5 years (to facilitate the transition at age 5), using data from six countries (Brazil, Ghana, India, Norway, Oman and the U.S.) (de Onis et al., 2007). The WHO defines overweight as a BMI above 1 SD and obesity as a BMI above 2 SD from the mean of the reference population of the WHO (WHO, 2015d).

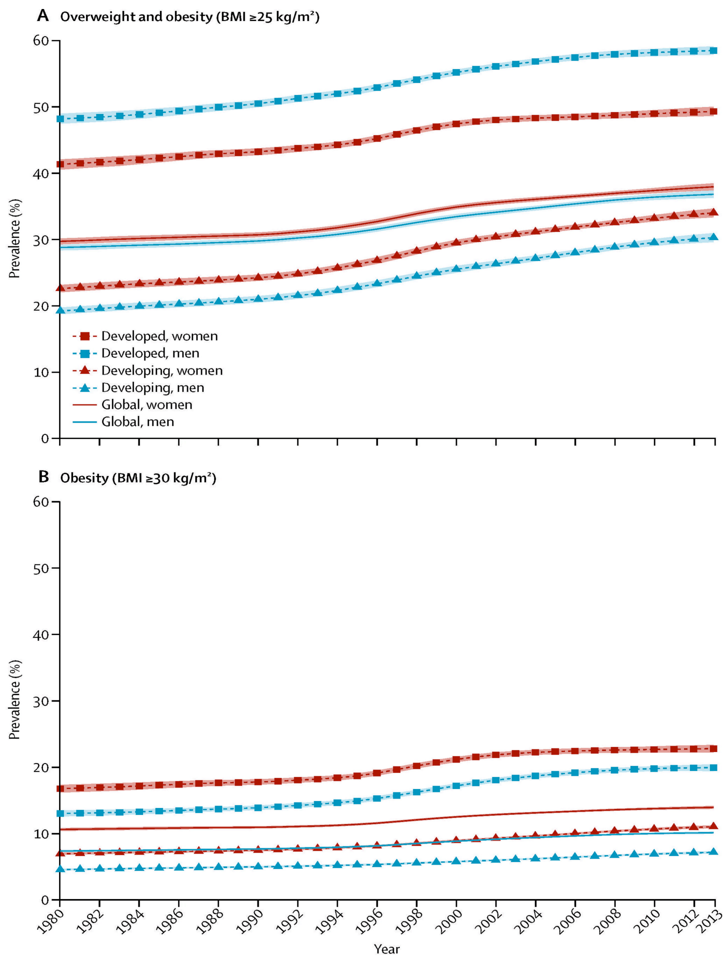
A recent study investigated the differences between the three BMI classification systems discussed above among a sample of children and adolescents aged 5-18 years (n=18,265). This study reported differences in the prevalence of overweight/obesity across three different classification systems used. The prevalence of overweight/obesity was highest using the WHO classification for both sexes and among all ages. The CDC classification provided the lowest prevalence of overweight and obesity among males, while the IOTF classification provided the lowest prevalence among females (Gonzalez-Casanova et al., 2013). These differences are reported across a number of studies (Fu et al., 2003; Khang & Park, 2011; Kovalskys, Rausch Herscovici, & De Gregorio, 2011). The difference in each classification systems among children aged 5-18 years in terms of objectives and sources explains the differences in prevalence estimations. The IOTF aimed to obtain an international reference (Cole, Bellizzi, Flegal, & Dietz, 2000); the CDC aimed to develop a reference for the U.S. population (Kuczmarsk et al., 2002), while the WHO aimed to have a non-obese sample and to obtain an equivalent of the healthy population (de Onis et al., 2007).

2.3. Overweight and Obesity

2.3.1. Prevalence of Overweight and Obesity

Obesity has become a worldwide public health concern as obesity rates have started to increase considerably not only in developed countries but also in developing countries. The WHO stated that the overall prevalence of overweight or obesity in developing countries is more than 30% higher than the prevalence in developed countries (WHO, 2013c). Also, the prevalence of overweight and obesity is increasing more slowly in developed countries as compared to the situation in developing countries (Ng et al., 2013). A systematic analysis was conducted to investigate the global prevalence of overweight and obesity among children and adults between 1980 and 2013. The results showed that the prevalence of overweight and obesity has increased by 28% for adults and 47% for children during this period. **Figure 2** shows this study's comparison of the prevalence of overweight and obesity in developed as compared to developing countries.

Figure 2. Age-standardized prevalence of overweight and obesity and obesity alone, ages ≥20 years, by sex, 1980–2013



Source: (Ng et al., 2013)

The prevalence of overweight and obesity in upper-income developing countries are higher than the prevalence in low-income developing countries. In Trinidad and Tobago (an English-speaking, upper-income developing country), a cross-sectional study conducted in 1999 among 5,688 children aged 5-9 years found that the prevalence of overweight and obesity were 8.5% and 2.4%, respectively (based on the 1990 British reference curves for BMI) (Gulliford, Mahabirb, Rockeb, Chinna, & Ronaa, 2001). A more recent study conducted in Barbados (a Caribbean country with a similar developmental and economic situation to Trinidad and Tobago) indicated that the prevalence of overweight and obesity among third grade students was relatively high at 35% in 2010 (based on the WHO growth reference) (Fernandez, Kubow, Gray-Donald, Knight, & Gaskin, 2015). In low-income developing countries, such as Tanzania, the prevalence of obesity is lower as compared to the prevalence in Caribbean countries. In a study conducted in 2008 among Tanzanian children aged 6-9 years (n=428), the prevalence of obesity was 5.6% among children living in Dodoma and 6.3% among children living in Kinondoni, and even lower among older children (10-12 years) (Mosha & Fungo, 2010).

In upper-income developing countries the prevalence of overweight and obesity is increasing considerably. Between 1990 and 1999, the prevalence of obesity among children in Dominica was found to have increased from 6% to 10%, while the prevalence among children in St. Kitts increased similarly from 7% to 11% (Xuereb et al., 2001). In Barbados, between 1981 and 2010 the prevalence of overweight and obesity increased rapidly from 9% to 33%, based on Harvard growth standards (Fernandez, Kubow, Gray-Donald, Knight, & Gaskin, 2015). In the study conducted in Dominica and St. Kitts, cut-offs and criteria used used to determine weight categories were not identified; thus, the data were not valid for comparisons. These studies was reported in the gray literature and published by Xuereb et al. 2001.

As obesity has become more prevalent, the concept of the "double burden of malnutrition" has emerged alongside the concept of the "nutrition transition," which came into use a few decades ago. The double burden of malnutrition is defined as the existence of under-nutrition, particularly among children, with a simultaneously increased prevalence of overweight and obesity as well as diet-related chronic diseases. The WHO reported that the double burden of malnutrition may exist at the same household in developing countries (Kennedy, Nantel, Shetty, & FAO, 2006; WHO, 2006). In developing countries, including the Caribbean, substantial efforts have been made to reduce under-nutrition (ACC/SCN, 2000; FAO, &WFP, 2015), but efforts to prevent obesity are still limited.

2.3.2. Health Consequences of Obesity

Children's weight gain above that of normal growth is a matter of concern, as it may lead to obesity and increase their risk later in life of developing non-communicable diseases, such as diabetes and coronary heart disease (Freedman, Khan, Dietz, Srinivasan, & Berenson, 2001). It has been reported that obese school-aged children are at higher risk of obesity as adults, as compared to their non-obese peers (Guo & Chumlea, 1999; Serdula et al., 1993a). Obese children and adolescents are at higher risk of hyperlipidemia, hypertension, and abnormal glucose tolerance, as compared to non-obese counterparts (Dietz, 1998; Romualdo, Nóbrega, & Escrivão, 2014; Shalitin, Abrahami, Lilos, & Phillip, 2005; Sorof & Daniels, 2002). Also, obese children are at risk of micronutrient deficiencies for a couple of reasons. One is that, obese individuals are more likely to consume unbalanced diet (high in calories and low in essential nutrients, e.g. iron, calcium and zinc) (Cepeda-Lopez, Aeberli, & Zimmermann, 2010; Pinhas-Hamiel et al., 2006; Schrager, 2005). Another reason is that the absorption of some nutrients, such as iron, may be reduced because of elevated levels of hepcidin that found to be increased with increased adiposity (Cepeda-Lopez, Aeberli, & Zimmermann, 2010; del Giudice et al., 2009).

2.3.3. Predictors of Obesity and Weight Gain

A number of predictors of overweight/obesity and weight gain have been identified. There are modifiable (e.g. diet and physical activity) and non-modifiable factors (e.g. age and sex). The majority of studies that investigated these predictors were conducted in developed countries, whereas the data in developing countries are limited. Basically, obesity and weight gain are caused by a lack of energy balance, where the energy is greater than the energy expenditure (Hill, Wyatt, & Peters, 2012).

1) Dietary components

Low intakes of fruit and vegetables. An inverse relationship between fruit and vegetable intake and adiposity has been shown in studies among adults (Ledoux, Hingle, & Baranowski, 2011); however, among children findings have been inconsistent. The association between higher fruit and vegetable intakes and reduced adiposity was evident in a longitudinal study in China among overweight children (n=95) ages 6-13 years (Wang, Ge, & Popkin, 2003). However, in another longitudinal study among American children aged 2-5 years (n=1,379) living in the North Dakota, no such association was found (Newby et al., 2003). This lack of association may be due to the use of a food frequency questionnaire as compared to the study done in China, which used three 24-hour dietary recalls to assess diet. Multiple 24-hour dietary recalls provide information regarding usual intake as well as descriptive details on food intake. Also, in the Chinese study, the children were older than the preschool-aged children in the American study, which may affect the relationship.

High intake of added sugars. As sugary drinks contribute to the largest portion of the children's consumption of added sugars (Reedy & Krebs-Smith, 2010), the relationship between the intake of sugar and sweetened beverages (SSB) and weight gain has become a concern. A number of studies have examined this relationship; however, the findings of these studies are inconsistent. Some studies have reported a lack of association between SSB and BMI (Blum, Jacobsen, & Donnelly, 2005; Forshee, Anderson, & Storey, 2004; Forshee & Storey, 2003; Johnson, Mander, Jones, Emmett, & Jebb, 2007), but a number of well designed experimental trials have shown that educational interventions and delivery of artificially sweetened soft drinks to replace other beverages were associated with weight reduction, but most studies were conducted among adults (Ebbeling et al., 2006; Raben, Vasilaras, Møller, & Astrup, 2002). Experimental trials among children are very limited, as this design requires careful planning to meet ethical standards. One cluster randomized controlled trial was conducted among 644 children aged 7-11 years using an educational intervention. Children in the control group (no education) had higher intake of SSB and greater weight gain (BMI z-score) as compared to children in the intervention group (James, Thomas, Cavan, & Kerr, 2004). Studies among adults that show no effect of SSB on weight gain may be due to the study design, sample size, dietary assessment methods, sources of sweeteners used (solid vs. liquid) and the types of sugars studied (Malik, Schulze, & Hu, 2006).

2) Low physical activity (PA). The WHO recommends a minimum of 60 minutes per day of moderate to vigorous-intensity PA for children (WHO, 2015c); however, the majority of children in a number of settings, including Canada and the U.S., are not meeting this recommendation (Colley et al., 2011; Dentro et al., 2014). Measuring children's PA is challenging and this may explain the lack of data regarding children's PA in developing countries (Welk, Corbin, & Dale, 2000). A low level of PA was associated with obesity among children in a number of studies (Hill, Wyatt, & Peters, 2012; O'Loughlin, Gray-Donald, Paradis, & Meshefedjian, 2000). The relationship between PA and weight status was confirmed decades ago; however, it was previously believed that low levels of PA caused obesity. When a number of PA interventions failed to reduce weight (Metcalf, Henley, & Wilkin, 2012), the direction of the causal relationship between PA and obesity was questioned. A recent study was conducted in an attempt to clarify the direction of the relationship. This prospective cohort study examined children aged 7-10 years and measured PA using accelerometers for seven consecutive days and percent of body fat by DEXA. Accelerometers have been validated and used to assess PA in a number of settings (Plasqui, Bonomi, & Westertero, 2013). The results of this study showed that a higher percentage of body fat predicted a decline in PA and PA levels did not predict changes in body fat (Metcalf et al., 2011).

3) Age and sex. Overweight and obesity are positively associated with age (Frye & Heinrich, 2003). In developed countries, overweight and obesity are more prevalent among men, while in developing countries, overweight and obesity are more prevalent among women (Ng et al., 2013). In addition, peak weight gain and height for girls is earlier than boys, but boys gain more weight overall. The average rate of weight gain for girls peaks at 8.3 kg per year at the age of 12.5 years and the height increase for girls peaks about 6 months earlier. The weight gain for boys peaks at 9 kg per year, peaking at the age of 14 years at the same time as their height increase peaks (Barnes, 1975; Tanner, 1965).

4) Parental BMI. Weight gain is complex and involves genetic and behavioral factors. Children are highly reliant on their parents to support their lifestyles, including diet and PA, which may have an effect on children's weight status. Despite the challenges of understanding the roles of genetics and the food environment in families, parental weight status is one of the strongest predictors of children's risk of obesity (Agras, Hammer, McNicholas, & Kraemer, 2004; Berkowitz, Stallings, Maislin, & Stunkard, 2005; O'Loughlin, Gray-Donald, Paradis, & Meshefedjian, 2000; Parikka et al., 2015; Whitaker, Wright, Pepe, Seidel, & Dietz, 1997; Wrotniak, Epstein, Paluch, & Roemmich, 2004).

5) Socioeconomic status (SES). Socioeconomic status is commonly measured as a combination of education, income and occupation (Kitagawa & Hauser, 1973). The relationship between SES and obesity among children in developing countries is not clear, as most studies were conducted among adults and a positive relationship was consistently reported in low-income developing countries. In wealthier and developed countries, SES is negatively associated with obesity only among women (Dinsa, Goryakin, Fumagalli, & Suhrcke, 2012; McLaren, 2007).

Parental education. Recently, education has become commonly used measure of SES in epidemiological studies, and it has been found to be strongly and consistently associated with all risk factors for cardiovascular disease (Winkleby, Jatulis, Frank, & Fortmann, 1992). Higher education level is inversely associated with overweight and obesity among children in developed countries (Apfelbacher et al., 2008; Frye & Heinrich, 2003). In low-income developing countries, education is associated positively with obesity, but in middle-income countries the results are mixed (Dinsa, Goryakin, Fumagalli, & Suhrcke, 2012). In a study conducted in Trinidad and Tobago, a high-income developing country, higher maternal education was associated with overweight and obesity among school-aged children aged 5-9 years (Gulliford, Mahabirb, Rockeb, Chinna, & Ronaa, 2001).

Household wealth. The relationship between wealth and health is clearly evident (Pollack, Chideya, Cubbin, Dekker, & Braveman, 2007). It has been reported that the "wealth index" or "asset index" is an important SES indicator of wealth and should be included in health studies (Pollack, Chideya, Cubbin, Dekker, & Braveman, 2007). The wealth index uses information on household ownership of durable goods and housing characteristics. The wealth index is a proxy measure that makes the best use of available data, which can be used when income and consumption data are unavailable (World Bank, 2003).

Assets offer a better measure of household wealth in developing countries than income and expenditure, as assets refer to accumulated wealth (Sherraden, 1991), while income is defined as the flow of resources (Fafchamps & Quisumbing, 2002; Fafchamps & Quisumbing, 2005; Filmer & Pritchett, 2001; Sahn & Stifel, 2000). However, a recent review reported that wealth indices are a poor proxy of consumption expenditure in low-income countries, while in middle-income countries wealth indices tend to have a stronger association with consumption expenditure (Howe, Hargreaves, Gabrysch, & Huttly, 2009).

Although the relationship between the wealth index and consumption expenditure is not evident in low-income countries, a relationship between the wealth index and nutritional health has been documented in some settings. A study in Bangladesh which used a 7-day food frequency instrument to study women in their first trimester of pregnancy, the authors found that the wealth index was positively associated with dietary diversity (Gunnsteinsson et al., 2010). Another study for children aged 0-59 months, which was part of the 2004 Bangladesh Demographic and Health Survey, reported an inverse association between household wealth and childhood stunting (Hong, Banta, & Betancourt, 2006). In upper-income developing countries, where it is difficult to collect data regarding income, the wealth index may provide a useful alternative for estimating wealth and predicting children's nutritional status.

6) Race and ethnicity. Cultural differences in terms of preferred body sizes and lack of overweight recognition are seen as explaining racial/ethnic differences in obesity prevalence (Caprio et al., 2008). African American men, for example, tend to prefer women with larger body sizes (Powell & Kahn, 1995). Also, genetic factors may play a role in body size and body composition. In a cross-sectional study conducted in 1999 among children aged 5-9 years in Trinidad and Tobago, the HFA z-score of Indo-Caribbean children was lower than the reference using British standard curves, while Afro-Caribbean children and children with mixed ethnicities had a higher HFA z-score than the reference. Also, WFA and BMI z-scores of Indo-Caribbean children were lower than the references (Gulliford, Mahabirb, Rockeb, Chinna, & Ronaa, 2001).

In summary, predictors of overweight and obesity, and weight gain are well studied in developed countries, while there is less longitudinal research in this area of predictors of obesity in developing countries.

2.4. Nutrient Imbalance

2.4.1. Micronutrient Deficiencies

Micronutrients are fundamental for an individual's health, growth and development. The WHO has recognized certain micronutrient deficiencies as points of concern in developing countries, including vitamin A, iodine and iron deficiency (WHO, 2013a, 2013b). Children, particularly, are at a high risk for these micronutrient deficiencies (WHO, 2013a). However, studies examining the prevalence of vitamin A, iodine and iron deficiencies in Jamaica and Guyana have found that iodine and vitamin A deficiencies are not a public health concern in these countries (FAO, 2003; Simmons, 1994). Fortification seems to assure adequate intake for these nutrients (ACC/SCN, 2000; PAHO, 1998). Despite the fortification of cereals and flour with iron, anemia is common and this manifestation of iron deficiency has been recognized as a significant health problem based on data from more than 20 years ago. The most recent report on anemia among children was collected from children aged 1-5 years (n=81) from Antigua and Barbuda, which used outdated data that were collected in 1997 (Mora, Boy, Lutter, & Grajeda, 2009; Simmons & Gurney, 1982).

A high intake of certain nutrients often leads to the replacement of essential nutrients in the diet. For example, data from the U.S. have shown that a high intake of added sugar is linked to poor intakes of iron, zinc and calcium (Murphy & Johnson, 2003). Recently, children have increased their consumption of added sugar, due to its high accessibility; this increased consumption is replacing essential nutrients (Rangan et al., 2012; WHO, 2013b). In response to this trend, a number of health organizations recommend limiting daily energy intake from added sugars. In 2010, the USDA recommended limiting added sugars and solid fats to 5-15% of total daily energy intake, while in 2009, the American Heart Association (AHA) recommended that women and men limit their energy intake from added sugars to 100 kcal and 150 kcal respectively (Johnson et al., 2009; USDA, 2010). In 2002, the Dietary Reference Intake (DRI) for added sugars was set at a much higher maximum of 25% of total energy intake (Murphy & Johnson, 2003). These added sugar guidelines were set to limit the possible adverse effects associated with excess energy from sugars, as well as the displacement of nutrient-dense foods (Murphy & Johnson, 2003; USDA, 2010). However, data are very limited regarding the displacement of nutrients. The most recent recommendation from the WHO limits the intake of added sugar to <10% of total energy intake to prevent weight gain and dental caries (WHO, 2015f).

2.4.2. Essentials of a Healthy Diet

Fruits and vegetables are an important part of a healthy diet, as they are an excellent source of vitamins, minerals and fiber. Children and adults in most countries, however, are consuming less than the minimum daily recommended intake (Pomerleau, Lock, McKee, & Altmann, 2004; WHO & FAO, 2002; WHO Europe, 2004). In fact, children in particular are at risk of not meeting the recommendations of fruit and vegetable intakes despite nutrition interventions (Knai, Pomerleau, Lock, & McKee, 2006). Fruits and vegetables are usually replaced by competitive unhealthy foods, such as sweets and candies, due to many factors, including taste preference and convenience (Krølner et al., 2011). Concerning changes in children's dietary patterns and weight status, recent data are needed to assess children's diet quality in developing countries. Fruit and vegetable availability is reported to be low in the Caribbean countries (Ballayram & Henry, 2008; CFNI & FAO, 2007); however, this may be underestimated as many local food sources are not counted in the economic figures (e.g. garden and neighborhood fruit trees).

Milk is the main source of calcium in the diet of children. In the U.S., studies reported a reduction in milk intake (largest drop in milk intake was occurred in children ages 2-18 years), which was linked to the increased intake of SSB; this was more evident in the older age groups (Nielsen & Popkin, 2004). In most developing countries, children are consuming only 1/3 to 1/2 of the daily recommendations of calcium (Pettifor, 2014). Also, individuals of African descent have low consumption of milk, this could be due to the concern for lactose intolerance among this population, despite the evidence that even lactose intolerant individuals are generally able to consume one cup of milk a day without experiencing symptoms, and those individuals also can take other measures to limit complications from lactose (Byers & Savaiano, 2005; Heaney, 2006). Low availability of milk may increase the risk of dietary inadequacy of calcium (FAO, 2007).

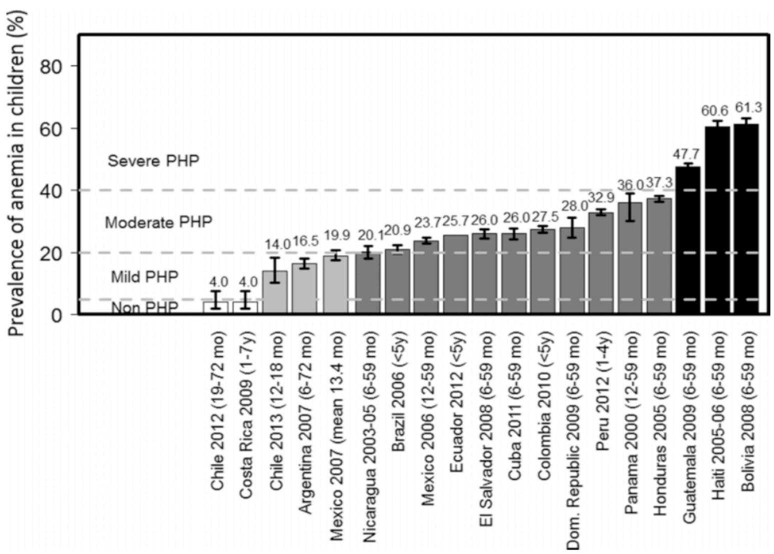
2.5. Anemia

2.5.1. Prevalence of Anemia

Anemia is a condition characterized by having a low number of red blood cells, or having red blood cells that contain a low hemoglobin level (National Heart Lung and Blood Insititute, 2012a). Anemia is a public health concern, particularly among young children and women in developing countries (ACC/SCN, 2000; WHO, 2013a). Among preschool-aged children, the prevalence of anemia in developing countries is 42% as compared to 17% in developed countries. The gap is even larger among older children, with 53% of school-aged children having anemia, as compared to 10% in developed countries (ACC/SCN, 2000). Although the prevalence of anemia among school-aged children in developing countries is particularly high, limited research has been conducted concerning anemia in this population. To compensate for a lack of data regarding anemia prevalence in a number of countries, the prevalence has been predicted by the WHO using regression models (McLean, Cogswell, Egli, Wojdyla, & de Benoist, 2009; WHO & CDC, 2008). These regression models were developed using data from countries with anemia prevalence and the 2002 United Nations Human Development Index (HDI) (UN, 2002) (a composite indicator of a life expectancy index, an education index, and a wealth index), and health indicators from the World Health Statistics Database (WHO, 2005).

Information pertaining to anemia among populations in the Caribbean is very limited. Data regarding anemia in the English-speaking Caribbean are outdated, as some studies were conducted as early as the 1960s. These early studies reported the lowest prevalence of anemia 9% among school-aged children in Barbados (cut-off <11.5 g/dL), while in Grenada, anemia was considered to be a severe public health problem with a prevalence of 65% among children aged 5-10 years (cut-off <12.0 g/dL) (Simmons & Gurney, 1982). A recent systematic review included studies that aimed to determine the prevalence of anemia among children under 6 years of age and women of childbearing age in Latin America included two Caribbean countries none of which are English-speaking Caribbean country. The prevalence of anemia among children under 6 years of age was not a public health problem in Chile or Costa Rica; it was a mild public health problem in Argentina and Mexico; moderate public health problem in Salvador, Cuba, Colombia, the Dominican Republic and Peru, and a severe public health problem in Guatemala, Haiti, and Bolivia (see **Figure 3)** (Mujica-Coopman et al., 2015). The classification of anemia prevalence is based on the prevalence of hemoglobin values below the population-specific hemoglobin threshold. This classification was used to classify countries by the level of severity of the public health problem, as seen in **Table 3** (WHO, 2001).

Figure 3. Prevalence of anemia among children under the age of 6 years in Latin America and the Caribbean



Source: (Mujica-Coopman et al., 2015)

Table 3. Classification of anemia as a problem of public health significance

Prevalence of anemia (%)	Category of public health significance
≤ 4.9	No public health problem
5.0-19.9	Mild public health problem
20.0-39.9	Moderate public health problem
≥ 40.0	Severe public health problem

Source: (WHO, 2001)

2.5.2. Health Consequences of Iron Deficiency among Children

Iron is an essential component of many proteins and enzymes in the human body. Iron is an important part of the hemoglobin molecule that plays a critical role in transferring oxygen from the lungs to the tissues in the body. Iron deficiency may result in weakness and fatigue that are due to tissue oxygen deprivation (Baker & Bick, 1993). The non-hematologic manifestations of iron deficiency among children include deleterious effects on brain function and decrease or suppress immune function (Beard, Connor, & Jones, 1993; Walter, Olivares, Pizarro, & Muñoz, 1997).

Cognitive performance is widely tested among school-aged children to examine the relationship between iron deficiency status and brain function. In a study of children and adolescents in the U.S. (data from the NHANES) researchers investigated the relationship between iron deficiency and cognitive achievement (assessed via math test scores). This study reported significantly lower math scores among children who were iron deficient with or without anemia as compared to children with normal iron status. Also, this study shows that the risk of scoring below the average of math test among iron deficient children was twice as high compared to children with normal iron status (odds ratio: 2.3; 95% confidence interval: 1.1-4.4) (Halterman, Kaczorowski, Aligne, Auinger, & Szilagyi, 2001). Such studies, however, are difficult to control for confounding, given that families of children with iron deficiency may be different to families where there is no iron deficiency.

2.5.3. Causes of Iron Deficiency

According to the American Society of Hematology, "iron deficiency anemia is the most common type of anemia (American Society of Hematology, 2015)," and an iron poor diet is the most frequent cause of iron deficiency among children (Oski, Brugnara, & Nathan, 2003; WHO, 2013a). The Estimated Average Requirement of iron for children aged 4-8 years is 4.1 mg/d, while it is 5.9 mg/d for male aged 9-13 years and 5.7 mg/d for females in the same age range (Institute of Medicine, 2001). A cross-sectional study investigated the correlate of anemia among toddlers aged 12-23 months (n=401) from two rural districts in India. The study reported that anemia was associated with low ferritin levels, as an indicator for iron storage levels, ferritin levels were also associated with iron intake (Pasricha et al., 2010). Poor bioavailability, malabsorption and systemic iron loss due to blood loses are other factors that may cause iron deficiency in children (Oski, Brugnara, & Nathan, 2003).

2.5.4. Food Sources of Iron

Foods containing heme iron from animal sources are highly bioavailable compared to non-heme iron from plant sources (Hallberg & Rossander, 1984). Heme iron is absorbed at 15-35% as compared to 2-20% for non-heme iron (Monson, 1988; Tapiero, Gate, & Tew, 2001). In addition, heme iron is not significantly affected by diet, as compared to non-heme iron, which is influenced by dietary components (Institute of Medicine, 2001; Monson, 1988). The FAO reported that, diets in low-income countries contain a lower proportion of heme iron, and absorbed iron is only about 5-10% (FAO, 1991). It has been confirmed that non-heme iron is absorbed more efficiently when consumed with heme iron or vitamin C (Institute of Medicine, 2001; Siegenberg et al., 1991). Intakes of calcium, polyphenol, phytates and oxalate with iron decrease or inhibit the absorption of iron (Institute of Medicine, 2001).

2.5.5. Stages of Iron Deficiency

Three stages are involved in the development of ron deficincy anemia which require multiple tests to be best distinguished (Gibson, 2005).

Stage 1. *Iron depletion* is characterized by a progressive reduction in stored iron in the liver. As the supply of iron is not compromised, the levels of transport iron and hemoglobin are not affected, but serum ferritin levels can detect depleted iron stores [6] (Cook, Lipschitz, Miles, & Finch, 1974). However, it is important to undrestand that ferritin is an acute phase

[6] Serum ferritin level is linked directly to iron stores.

protein; thus, serum ferritin levels are affected by factors other than iron stores, including infections and inflammatory disorders (Valberg, 1980). Also, higher levels of serum ferritin are associated with increased BMI and elevated levels of plasma glucose (Tuomainen et al., 1997). Higher levels of total iron-binding capacity (TIBC) [7] can also reflect the depletion of iron storage, but less precise than the serum ferritin (Institute of Medicine, 2001).

Stage 2. *Iron-deficient erythropoiesis,* or iron deficiency without anemia is characterized by the exhaustion of iron stores due to limited red blood cell production. This is a result of dietary iron intake insufficiency followed by depletion of iron stores. Hemoglobin levels are likely to remain within the normal range in this stage, or to decline slightly, as the duration of iron insufficiency may not be long enough to produce microcytic red cells (Longo et al., 2011). Low serum transferrin saturation [8] and high erythrocyte protoporphyrin concentration may indicate iron deficiency, but it is important to understand that neither test specifically measures iron deficiency. Soluble serum transferrin receptor concentration (sTfR) [9] is a specific and sensitive indicator of mild iron deficiency, even in the presence of chronic diseases, infection or inflammation (Institute of Medicine, 2001).

Stage 3. *Iron deficiency anemia* is the final stage of iron deficiency, which is characterized by the exhaustion of iron stores, lower levels of iron in the circulation, as well as the existence of microcytic, hypochromic anemia. The reduction of hemoglobin and hematocrit levels in the red blood cells is the main feature of this stage. Hemoglobin level is commonly used to assess anemia as hematocrit levels tend to fall in the late stages of iron deficiency after the hemoglobin level falls (Gibson, 2005).

---

[7] TIBC is the total quantity of iron bound to transferrin after the addition of exogenous iron to plasma.
[8] Transferrin saturation is the ratio of serum iron and TIBC.
[9] TfR is an iron-related protein that regulates the uptake of transferrin iron into all body cells. The surfaces of the cells express TfRs in proportion to their iron requirement.

2.5.6. Measures of Iron Status to Diagnose Anemia

The hemoglobin concentration measure is the most commonly used test to screen for anemia. The WHO cut-off point for hemoglobin levels in identifying anemia among children aged 5-11 years is <11.5 g/dL and <12.0 g/dL for children aged 12-14 years (WHO & CDC, 2008). The use of multiple indicators is recommended to avoid misclassification, e.g. serum ferritin, TIBC, transferrin saturation and sTfR. Even though it is not recommended to use hemoglobin level alone to measure iron status in optimal situations (Gibson, 2005), it could be used as an indicator of iron deficiency anemia in developing countries (Kotecha, 2011). The ferritin model and the mean cell volume (MCV) model, which were described by the Expert Scientific Working Group in 1985 and which provide similar results, are used in epidemiological studies to improve the specificity of the hemoglobin concentration as an indicator of iron deficiency anemia. The ferritin model includes a combination of indicators, which include serum ferritin concentration, erythrocyte protoporphyrin concentration, and transferrin saturation, while the MCV model includes MCV, transferrin saturation, and erythrocyte protoporphyrin concentration. In both models, two or more abnormal indicators indicate iron deficiency (Institute of Medicine, 2001).

Venous blood is best for measuring hemoglobin concentration, but capillary blood from heel-, ear- or finger-pricks can also be used, although the latter is considered to be a less precise measurement (WHO, UNICEF, & UNU, 2001). A capillary blood sample is less precise because it may provide a lower value due to the interstitial fluid diluting the samples (Burger & Pierre-Louis, 2003) or the sample may provide a higher estimate due to a number of factors leading to a higher concentration of red blood cells in the extremities, where one such factor is the body position before the collection of the sample (Neufeld et al., 2002). Also, the capillary sample could reflect a high concentration of red blood cells in the extremities due to a number of factors, including the position of the body before the test (Patel, Wesley, Leitman, & Bryant, 2013). The "HemoCue" is a portable hemoglobin photometer, which is used mainly in research conducted in remote settings. Accuracy and precision of results using HemoCue to measure hemoglobin levels are comparable to results using the cyanmethemoglobin method (Von Schenck, Falkensson, & Lundberg, 1986), which is a method recommended by the International Committee for Standardization in Hematology (International Committee for Standardization in Hematology, 1978). Standardized procedures should be followed to increase accuracy and reliability of hemoglobin concentrations measured by HemoCue (Burger & Pierre-Louis, 2003).

Previous studies reported lower hemoglobin concentrations when measured using a capillary sample as compared to when venous blood sample was used. This was explained by the interstitial fluid that diluted the sample. However, more recent studies have reported a higher hemoglobin concentration as measured using a capillary sample (Neufeld et al., 2002; Patel, Wesley, Leitman, & Bryant, 2013). A study was conducted to investigate the influence of type of blood and analysis method (capillary using HemoCue vs. venous using Celldyn) for estimating the prevalence of anemia. The study found that assessing the hemoglobin concentration in capillary blood using HemoCue provided a higher estimate of hemoglobin (+0.5 g/dl) as compared to Celldyn, but the estimate of anemia prevalence among children was adequate with a specificity of 0.93 and sensitivity of 0.84 (Neufeld et al., 2002). So given the lower sensitivity, capillary blood samples taken by a HemoCue will result in underestimating the problem of anemia among the population under study.

2.5.7. Factors Affecting Hemoglobin Concentrations

There are a number of important factors that need to be considered when evaluating anemia status among school-aged children. Age and sex are important factors to consider when using hemoglobin concertation to assess anemia, as biological differences between boys and girls do exist. Girls tend to have a higher hemoglobin concentration before the age of 12 as compared to boys (Gibson, 2005).

Race also has an effect on hemoglobin concentration, as it has been shown that individuals of African descent tend to have 0.5-1.0 g/dL lower hemoglobin concentration than Caucasians, regardless of age, income or iron deficiency status (Gibson, 2005). In a sample from four cohorts of low-income preschool children in the U.S., children of African descent had greater odds of incident anemia than Caucasian children (OR, 1.84-2.09), while Native American children had lower odds at 36 and 48 months of age (OR, 0.68, 0.65). These variations in hemoglobin concentration across different ethnicities/races occur due to standard differences in how the globin protein is genetically controlled (United States Department of the Air Force & United States Department of the Army, 1973). Therefore, race-specific cut-offs used to diagnose anemia should be used to assess individuals of African descent (Johnson-Spear & Yip, 1994). The WHO/UNICEF/UNU recommends using race-specific cut-offs to diagnose anemia among individuals of African descent, in which case the cut-off should be reduced by 1 g/dL (Gibson, 2005; Johnson-Spear & Yip, 1994).

Also, there are certain types of blood diseases that have been found to be more prevalent among individuals of African descent, such as sickle cell diseases. These diseases are also reported to be prevalent among Caribbean individuals (National Heart Lung and Blood Insititute, 2012b). When information regarding the individuals' history of blood disease and multiple biochemical tests for iron status are not available, approaches such as “the hemoglobin distribution” can be used to determine if the anemia is caused by dietary factors or not. Hemoglobin distribution is used to evaluate iron status of a population by comparing hemoglobin distributions for men, women and children of the study population with hemoglobin distributions of a healthy reference sample. When anemia is prevalent, hemoglobin distribution will be shifted to the left of the reference distribution. If hemoglobin distributions of women and children are shifted to the left of the reference distribution and the distribution for men remains unaffected, poor iron intake is likely the main factor for the iron deficiency (Gibson, 2005). This is due to the higher dietary iron requirements for women and children, which are more difficult to meet, as compared to the iron requirements for adult men. If all age sex groups have low hemoglobin levels, other causes of anemia are suspected.

Due to the dramatic increase in the prevalence of obesity globally, more research has been conducted to examine the association of obesity and anemia. Anemia has been found to be more prevalent among obese individuals (Cepeda-Lopez, Aeberli, & Zimmermann, 2010; Sharif, Madani, & Tabatabaie, 2014). However, the reported iron intake of overweight children and children within a normal weight range is not different (Aeberli, Kaspar, & Zimmermann, 2007). One possible explanation is that iron absorption may be reduced in obese children due to elevated levels of circulating hepcidin, which is the iron regulatory hormone (Cepeda-Lopez, Aeberli, & Zimmermann, 2010; del Giudice et al., 2009). Another explanation is that overweight and obese individuals have higher iron requirements due to higher blood volume and higher basal iron losses (the requirement was calculated based on a healthy body weight) (Trumbo, Yates, Schlicker, & Poos, 2001). Tests such as serum iron, TIBC, and transferrin saturation are recommended when assessing anemia among populations with a high prevalence of overweight and obesity, as these measurements are useful to distinguish between nutritional iron deficiency and anemia caused by inflammation (Gibson, 2005).

2.6. Conclusion

This review summarizes the findings of the literature pertaining to food insecurity and nutritional health, with a focus on diet, growth, obesity and anemia among school-aged children in developing countries. It can be concluded that children in developing countries are at a higher risk of food insecurity, obesity and anemia, as compared to children in developed countries. The association between food insecurity and growth is only evident in low-income settings, while the relationship between food insecurity and diet as well as anemia is evident regardless of country income or level of development. In developing countries, data regarding predictors of obesity are limited and rates of anemia are rarely measured. The studies described in the next three chapters were designed to investigate the issue of food insecurity and its effect on children's nutritional health, the determinants of overweight and obesity, and anemia and its correlates among Caribbean school-aged children aged 6-12 years.

2.7. References

Abdulai, A., & Aubert, D. (2004). Nonparametric and parametric analysis of calorie consumption in Tanzania. *Food Policy, 29*(2), 113-129.

ACC/SCN. (2000). Fourth report on the world nutrition situation: nutrition throughout the life cycle. Retrieved May 14th, 2016, from: http://www.unscn.org/layout/modules/resources/files/rwns4.pdf

ADA. (2003). What is the relationship between household food insecurity and childhood overweight? Retrieved Nov 10th, 2015, from: http://www.andeal.org/topic.cfm?cat=4159&conclusion_statement_id=39&highlight=food insecurity obesity children&home=1

Aeberli, I., Kaspar, M., & Zimmermann, M. B. (2007). Dietary intake and physical activity of normal weight and overweight 6 to 14 year old Swiss children. *Swiss Med Wkly, 137*(29), 424-430.

Agras, W. S., Hammer, L. D., McNicholas, F., & Kraemer, H. C. (2004). Risk factors for childhood overweight: a prospective study from birth to 9.5 years *J Pediatr, 145*(1), 20-25.

American Society of Hematology. (2015). Anemia. Retrieved Nov 10th, 2015 from: http://www.hematology.org/Patients/Anemia/

Apfelbacher, C., Loerbroks, A., Cairns, J., Behrendt, H., Ring, J., & Kramer, U. (2008). Predictors of overweight and obesity in five to seven-year-old children in Germany: results from cross-sectional studies. *BMC Public Health, 8*(171).

Baker, W. F., & Bick, R. L. (1993). Iron deficiency anemia. *Hematology: Clinical and laboratory practice book*. St. Louis: Mosby.

Ballayram., & Henry, F. (2008). Food and nutrition security in CARIFORUM countries. *CAJANUS, 4*.

Baranowski, T., Baranowski, J. C., Watson, K. B., Martin, S., Beltran, A., Islam, N., . . . Subar, A. (2011). Children's accuracy of portion size estimation using digital food images: effects of interface design and size of image on computer screen. *Public Health Nutr, 14*(3), 418-425.

Baranowski, T., Islam, N., Baranowski, J., Martin, S., Beltran, A., Dadabhoy, H., . . . Subar, A. F. (2012). Comparison of a web-based versus traditional dietary recall among children. *J Am Diet Assoc, 112*(4), 527-532.

Barnes, H. V. (1975). Physical growth and development during puberty. *Med Clin North Am, 59*(6), 1305-1317.

Beard, J. L., Connor, J. D., & Jones, B. C. (1993). Brain iron: location and function *Prog Food Nutr Sci, 17*(3), 183-221.

Berkowitz, R. I., Stallings, V. A., Maislin, G., & Stunkard, A. J. (2005). Growth of children at high risk of obesity during the first 6 y of life: implications for prevention. *Am J Clin Nutr, 81*(1), 140-146.

Bhargava, A., Jolliffe, D., & Howard, L. L. (2008). Socio-economic, behavioural and environmental factors predicted body weights and household food insecurity scores in the early childhood longitudinal study-kindergarten. *Br J Nutr, 100*(2), 438-444.

Bhattacharya, J., Currie, J., & Haider, S. (2004). Poverty, food insecurity, and nutritional outcomes in children and adults. *J Health Econ, 23*(4), 839-862.

Bickel, G., Nord, M., Price, C., Hamilton, W., & Cook, J. (2000). Guide to measuring household food security. Retrieved May 10th, 2015, from: http://www.fns.usda.gov/guide-measuring-household-food-security-revised-2000

Black, A. E. (2000). The sensitivity and specificity of the Goldberg cut-off for EI:BMR for identifying diet reports of poor validity. *Eur J Clin Nutr, 54*(5), 395-404.

Black, A. E., & Cole, T. J. (2000). Within- and between-subject variation in energy expenditure measured by the doubly-labelled water technique: implications for validating reported dietary energy intake. *Eur J Clin Nutr, 54*(5), 386-394.

Black, R. E., Allen, L., Bhutta, Z. A., Caulfield, L. E., de Onis, M., Ezzati, M., . . . Maternal and Child Undernutrition Study Group. (2008). Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet, 371*(9608), 243-260.

Blum, J. W., Jacobsen, D. J., & Donnelly, J. E. (2005). Beverage consumption patterns in elementary school aged children across a two-year period. *J Am Coll Nutr, 24*(2), 93-98.

Börnhorst, C., Huybrechts, I., Ahrens, W., Eiben, G., Michels, N., Pala, V., . . . IDEFICS consortium. (2013). Prevalence and determinants of misreporting among European children in proxy-reported 24 h dietary recalls. *Br J Nutr, 109*(7), 1257-65.

Brion, M. J., Ness, A. R., Rogers, I., Emmett, P., Cribb, V., Davey Smith, G., & Lawlor, D. A. (2010). Maternal macronutrient and energy intakes in pregnancy and offspring intake at 10 y: exploring parental comparisons and prenatal effects. *Am J Clin Nutr, 3*(91), 748-756.

Burger, S., & Pierre-Louis, J. (2003). *A procedure to estimate the accuracy and reliability of HemoCue™ measurements of survey workers*. Retrieved from Washington, DC:

Burrows, T. L., Martin, R. J., & Collins, C. E. (2010). A systematic review of the validity of dietary assessment methods in children when compared with the method of doubly labeled water. *J Am Diet Assoc, 110*(10), 1501-1510.

Byers, K. G., & Savaiano, D. A. (2005). The myth of increased lactose intolerance in African-Americans. *J Am Coll Nutr, 24*(6), 569S-573S.

Cafiero, C., Melgar-Quiñonez, H. R., Ballard, T. J., & Kepple, A. W. (2014). Validity and reliability of food security measures. *Ann N Y Acad Sci, 1331*, 230-248.

Campbell, C., Desjardins, E. (1989). A model and research approach for studying the management of limited food resources by low income families. *J Nutr Edu, 21*(4),162-171.

Caprio, S., Daniels, S., Drewnowski, A., Kaufman, F. R., Palinkas, L. A., Rosenbloom, A. L., & Schwimmer, J. B. (2008). Influence of race, ethnicity, and culture on childhood obesity: implications for prevention and treatment. *Diabetes Care, 31*(11), 2211-2221.

Cepeda-Lopez, A. C., Aeberli, I., & Zimmermann, M. B. (2010). Does obesity increase risk for iron deficiency? a review of the literature and the potential mechanisms. *Int J Vitam Nutr Res, 80*(4), 263-270.

CFNI, & FAO. (2007). *Overview vulnerability and food and nutrition security in the Caribbean*. Retrieved May 10th, 2016 from: http://s3.amazonaws.com/zanran_storage/www.euacpcommodities.eu/ContentPages/2465803400.pdf

Cole, T. J., Bellizzi, M. C., Flegal, K. M., & Dietz, W. H. (2000). Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ, 6;320*(7244), 1240-1243.

Cole, T. J., Faith, M. S., Pietrobelli, A., & Heo, M. (2005). What is the best measure of adiposity change in growing children: BMI, BMI%, BMI z-score or bmi centile? *Eur J Clin Nutr, 59*(3), 419-425.

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011). Physical activity of Canadian children and youth: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Rep, 22*(1), 15-23.

Cook, J. D., Lipschitz, D. A., Miles, L. E., & Finch, C. A. (1974). Serum ferritin as a measure of iron stores in normal subjects. *Am J Clin Nutr, 27*(7), 681-687.

Cordain, L., Eaton, B., Sebastian, A., Mann, N., Lindeberg, S., Watkins, B. A., . . . Brand-Miller, J. (2005). Origins and evolution of the Western diet: health implications for the 21st century. *Am J Clin Nutr, 81*(2), 14.

Cordeiro, L. S., Wilde, P. E., Semu, H., & Levinson, F. J. (2012). Household food security is inversely associated with undernutrition among adolescents from Kilosa, Tanzania. *J Nutr, 142*(9), 1741-1747.

Cordeiro, M. M., Monego, E. T., & Martins, K. A. (2014). Overweight in Goiás'quilombola students and food insecurity in their families. *SciELO, 27*(4), 405-412.

de Onis, M., Onyango, A. W., Borghi, E., Siyam, A., Nishida, C., & Siekmann, J. (2007). Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ, 85*(9), 660-667.

del Giudice, E. M., Santoro, N., Amato, A., Brienza, C., Calabrò, P., Wiegerinck, E. T., . . . Perrone, L. (2009). Hepcidin in obese children as a potential mediator of the association between obesity and iron deficiency. *J Clin Endocrinol Metab, 94*(12), 5102-5107.

Dell'Aquila, C., Ford, D., & Conforti, P. (2007). Agricultural trade policy and food security in the Caribbean: structural issues, multilateral negotiations and competitiveness. Rome: FAO, Trade and Markets Division.

Dentro, K. N., Beals, K., Crouter, S. E., Eisenmann, J. C., McKenzie, T. L., Pate, R. R., . . . Katzmarzyk, P. T. (2014). Results from the United states' 2014 report card on physical activity for children and youth. *J Phys Act Health, 11*(1), s105-112.

Dietz, W. H. (1998). Health consequences of obesity in youth: childhood predictors of adult disease. *Pediatrics, 101*(3), 518-525.

Dinsa, G. D., Goryakin, Y., Fumagalli, E., & Suhrcke, M. (2012). Obesity and socioeconomic status in developing countries: a systematic review. *Obes Rev, 13*(11), 1067-1079.

Dwyer, T., & Blizzard, C. L. (1996). Defining obesity in children by biological endpoint rather than population distribution. *Int J Obes Relat Metab Disord, 20*(5), 472-480.

Ebbeling, C. B., Feldman, H. A., Osganian, S. K., Chomitz, V. R., Ellenbogen, S. J., & Ludwig, D. S. (2006). Effects of decreasing sugar-sweetened beverage consumption on body weight in adolescents: a randomized, controlled pilot study. *Pediatr, 117*(3), 673-680.

Eck, L. H., Klesges, R. C., & Hanson, C. L. (1989). Recall of a child's intake from one meal: are parents accurate? *J Am Diet Assoc, 89*, 784-787.

Eicher-Miller, H. A., Mason, A. C., Weaver, C. M., McCabe, G. P., & Boushey, C. J. (2009). Food insecurity is associated with iron deficiency anemia in US adolescents. *Am J Clin Nutr, 90*(5), 1358-1371.

Eisenmann, J. C., Gundersen, C., Lohman, B. J., Garasky, S., & Stewart, S. D. (2011). Is food insecurity related to overweight and obesity inchildren and adolescents? a summary of studies,1995–2009. *Obes Rev, 12*(5), e73-e83.

Fafchamps, M., & Quisumbing, A. (2002). Control and ownership of assets within rural Ethiopian households. *J Devel Stud, 38*(6), 47-82.

Fafchamps, M., & Quisumbing, A. (2005). Assets at marriage in rural Ethiopia. *J Devel Econ, 77*(1), 1-25.

FAO. (1991). *Requirements of vitamin a, iron, folate and vitamin b12. Report of joint FAO/WHO expert consultation. 107 seiten, 5 abb., 24 tab. Food and Agriculture Organization of the United Nations; Rome.*

FAO. (1996). Rome declaration on world food security and world and world food summit plan of action. Retrieved Nov 21st, 2015, from: http://www.fao.org/docrep/003/w3613e/w3613e00.HTM

FAO. (2002). *Measurement and assessment of food deprivation and undernutrition*. Paper presented at the International Scientific Symposium, Rome. Retrieved Nov 21st, 2015, from: http://www.fao.org/docrep/005/y4250e/y4250e00.htm

FAO. (2003). *Nutrition country profile of Trinidad and Tobago*. Retrieved Nov 21st, 2015, from: ftp://ftp.fao.org/ag/agn/nutrition/ncp/ttomap.pdf

FAO. (2004). Promoting the expression "food and nutrition security (FNS)". Retrieved Nov 21st, 2015, from: http://www.fao.org/ag/agn/nutrition/docs/Food_and_Nutrition_Security-Strategy_Note.pdf

FAO. (2007). *Agricultural trade policy and food security in the Caribbean: structural issues, multilateral negotiations and competitiveness*, Rome. Retrieved Nov 21st, 2015, from: http://www.fao.org/docrep/010/a1146e/a1146e01.pdf

FAO. (2013). *The food insecurity experience scale*. Retrieved Nov 21st, 2015, from: http://www.fao.org/fileadmin/templates/ess/voh/FIES_Technical_Paper_v1.1.pdf

FAO. (2015). *Regional overview of food insecurity Latin America and the Caribbean*. Retrieved Nov 21st, 2015, from: http://reliefweb.int/sites/reliefweb.int/files/resources/Regional Overview of Food Insecurity Latin America and the Caribbean.pdf

FAO, & WFP. (2015). *The state of food insecurity in the world 2015, meeting the 2015 international hunger targets: taking stock of uneven progress,* Rome. Retrieved Nov 21st, 2015, from: http://www.fao.org/3/a-i4646e.pdf

Feferbaum, R., de Abreu, L. C., & Leone, C. (2012). Fluid intake patterns: an epidemiological study among children and adolescents in Brazil. *BMC Public Health, 12*(1), 1-7.

Fernandez, M. A., Kubow, S., Gray-Donald, K., Knight, J., & Gaskin, P. S. (2015). Drastic increases in overweight and obesity from 1981 to 2010 and related risk factors: results from the Barbados children's health and nutrition study. *Public Health Nutr*, 1-8.

Filmer, D., & Pritchett, L. (2001). Estimating wealth effects without expenditure data – or tears: an application to educational enrollment in states of India. *Demography, 38*(1), 115-132.

Forshee, R. A., Anderson, P. A., & Storey, M. L. (2004). The role of beverage consumption, physical activity, sedentary behavior, and demographics on body mass index of adolescents. *Int J Food Sci Nutr, 55*(6), 463-478.

Forshee, R. A., & Storey, M. L. (2003). Total beverage consumption and beverage choices among children and adolescents. *Int J Food Sci Nutr, 54*(4), 297-307.

Freedman, D. S., Khan, L. K., Dietz, W. H., Srinivasan, S. A., & Berenson, G. S. (2001). Relationship of childhood obesity to coronary heart disease risk factors in adulthood: the Bogalusa heart study. *Pediatrics, 108*(3), 712–718.

Frye, C., & Heinrich, J. (2003). Trends and predictors of overweight and obesity in East German children. *Int J Obes Relat Metab Disord, 27*(8), 963-969.

Fu, W. P., Lee, H. C., Ng, C. J., Tay, Y. K., Kau, C. Y., Seow, C. J., . . . Hong, C. Y. (2003). Screening for childhood obesity: international vs population-specific definitions. Which is more appropriate? *Int J Obes Relat Metab Disord, 27*(9), 1121-1126.

Gibson, R. S. (2005). *Principles of nutritional assessment* (2nd ed.). New York: Oxford University Press.

Gonzalez-Casanova, I., Sarmiento, O. L., Gazmararian, J. A., Cunningham, S. A., Martorell, R., Pratt, M., & Stein, A. D. (2013). Comparing three body mass index classification systems to assess overweight and obesity in children and adolescents. *Rev Panam Salud Publica, 33*(5), 349-355.

Gross, R., Schoeneberger, H., Pfeifer, H., & Preuss, H.-J. A. (2000). The four dimensions of food and nutrition security: definitions and concepts. Retrieved Nov 6th, 2015, from: http://www.fao.org/elearning/course/fa/en/pdf/p-01_rg_concept.pdf

Gulliford, M. C., Mahabir, D., & Rocke, B. (2004). Reliability and validity of a short form household food security scale in a Caribbean community. *BMC Public Health, 4*(22).

Gulliford, M. C., Mahabir, D., Rocke, B., Chinn, S., & Rona, R. (2001). Overweight, obesity and skinfold thiknesses of children of African or Indian Descent in Trinidad and Tobago. *Int J Epidemiol, 30*(5), 989-998.

Gulliford, M. C., Nunes, C., & Rocke, B. (2006). The 18 household food security survey items provide valid food security classifications for adults and children in the Caribbean. *BMC Public Health, 6*(26).

Gunnsteinsson, S., Labrique, A. B., West, K. P., Christian, P., Mehra, S., Shamim, A.-A., . . . Klemm, R. D. (2010). Constructing indices of rural living standards in Northwestern Bangladesh. *J Health Popul Nutr, 28*(5), 509-519.

Guo, S. S., & Chumlea, W. C. (1999). Tracking of body mass index in children in relation to overweight in adulthood. *Am J Clin Nutr, 70*(1), 145s–148s.

Hackett, M., Melgar-Quinonez, H., & Alvarez, M. C. (2009). Household food insecurity associated with stunting and underweight among preschool children in Antioquia, Colombia. *Rev Panam Salud Publica, 25*(6), 506-510.

Hallberg, L., & Rossander, L. (1984). Improvement of iron nutrition in developing countries: comparison of adding meat, soy protein, ascorbic acid, citric acid and ferrous sulphate on iron absorption from a simple Latin American-type of meal. *Am J Clin Nutr, 39*(4), 577-583.

Halterman, J. S., Kaczorowski, J. M., Aligne, C. A., Auinger, P., & Szilagyi, P. G. (2001). Iron deficiency and cognitive achievement among school-aged children and adolescents in the United States. *Pediatrics, 107*(6), 1381-1386.

Handa, S., & King, D. (2003). Adjustment with a human face? evidence from Jamaica. *World Development, 31*(7), 1125-1145.

Heaney, R. P. (2006). Low calcium intake among African Americans: effects on bone and body weight. *J Nutr, 136*(4), 1095-1098.

Hill, J. O., Wyatt, H. R., & Peters, J. C. (2012). Energy balance and obesity. *Circulation, 126*(1), 126-132.

Hong, R., Banta, J. E., & Betancourt, J. A. (2006). Relationship between household wealth inequality and chronic childhood under-nutrition in Bangladesh. *Int J Equity Health, 5*(15).

Howe, L. D., Hargreaves, J. R., Gabrysch, S., & Huttly, S. R. (2009). Is the wealth index a proxy for consumption expenditure? a systematic review *J Epidemiol Community Health, 63*(11), 871-877.

Hughes, A. R., Sherriff, A., Lawlor, D. A., Ness, A. R., & Reilly, J. J. (2011). Timing of excess weight gain in the Avon longitudinal study of parents and children (ALSPAC). *Pediatrics, 127*(3), e730-736.

Hulley, S. B., Cummings, S. R., Browner, W., & Grady, D. G. (2013). Planning the measurements: precision, accuracy, and validity. *Designing clinical research* (4 ed., pp. 378). Philadelphia: Wolters Kluwer.

Humphries, D. L., Dearden, K. A., Crookston, B. T., Fernald, L. C., Stein, A. D., Woldehanna, T., . . . Young Lives Determinants and Consequences of Child Growth Project Team. (2015). Cross-sectional and longitudinal associations between household food security and child anthropometry at ages 5 and 8 years in Ethiopia, India, Peru, and Vietnam. *J Nutr, 145*(8), 1924-1933.

Institute of Medicine. (2000). *Dietary reference intakes: applications in dietary assessment: a report of the subcommittees on interpretation and uses of dietary reference intakes and upper reference levels of nutrients, and the standing committee on the scientific evaluation of dietary reference intakes.* Washington, D.C: National Academy Press.

Institute of Medicine. (2001). *Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium and zinc*. Washington, D.C: National Academy Press.

International Committee for Standardization in Hematology. (1978). Recommendations for measurement of serum iron in human blood. *Br J Haematology, 38*(2), 1365-2141.

Isanaka, S., Mora-Plazas, M., Lopez-Arana, S., Baylin, A., & Villamor, E. (2007). Food insecurity is highly prevalent and predicts underweight but not overweight in adults and school children from Bogotá, Colombia. *J Nutr, 137*(12), 2747-2755.

Jahns, L., Arab, L., Carriquiry, A., & Popkin, B. (2004). The use of external within-person variance estimates to adjust nutrient intake distributions over time and across populations. *Public Health Nutr, 8*(1), 69-78.

James, J., Thomas, P., Cavan, D., & Kerr, D. (2004). Preventing childhood obesity by reducing consumption of carbonated drinks: cluster randomised controlled trial. *BMJ, 328*(7450), 1237.

Johnson, R. K., Appel, L. J., Brands, M., Howard, B. V., Lefevre, M., Lustig, R. H., . . . Wylie-Rosett, J. (2009). Dietary Sugars intake and cardiovascular health: a scientific statment from the American heart association. *Circulation, 120*, 10.

Johnson, L., Mander, A. P., Jones, L. R., Emmett, P. M., & Jebb, S. A. (2007). Is sugar-sweetened beverage consumption associated with increased fatness in children? *Nutrition, 23*(7-8), 557-563.

Johnson-Spear, M. A., & Yip, R. (1994). Hemoglobin difference between black and white women with comparable iron status: justification for race-specific anemia criteria. *Am J Clin Nutr, 60*(1), 117-121.

Jyoti, D. F., Frongillo, E. A., & Jones, S. J. (2005). Food insecurity affects school children's academic performance, weight gain, and social skills. *J Nutr, 135*(12), 2831-2839.

Kakinami, L., Henderson, M., Chiolero, A., Cole, T. J., & Paradis, G. (2014). Identifying the best body mass index metric to assess adiposity change in children. *Arch Dis Child, 99*(11), 1020-1024.

Kendall, A., Olson, C. M., & Frongillo, E. A. (1996). Relationship of hunger and food insecurity to food availability and consumption. *J Am Diet Assoc, 96*(10), 1019-1024; quiz 1025-1016.

Kennedy, G., Nantel, G., Shetty, P., & FAO. (2006). The double burden of malnutrition case studies from six developing countries. Retrieved Nov 21st, 2015, from: ftp://ftp.fao.org/docrep/fao/009/a0442e/a0442e00.pdf

Khang, Y. H., & Park, M. J. (2011). Trends in obesity among Korean children using four different criteria. *Int J Pediatr Obes, 6*(3-4), 206-214.

Kilanowski, J. F., & Lin, Li. (2012). Rasch analysis of US household food security survey module in Latino migrant farmworkers. *J Hunger Environ Nutr, 7*(2-3), 178-191.

Kirkpatrick, S. I., Dodd, K. W., Parsons, R., Ng, C., Garriguet, D., & Tarasuk, V. (2015). Household food insecurity is a stronger marker of adequacy of nutrient intakes among Canadian compared to American youth and adults. *J Nutr, 145*(7).

Kirkpatrick, S. I., & Tarasuk, V. (2008). Food insecurity is associated with nutrient inadequacies among Canadian adults and adolescents. *J Nutr, 138*(3), 9.

Kitagawa, E. M., & Hauser, P. M. (1973). *Differential mortality in the United States: a study in socioeconomic epidemiology* (1 ed.). Cambridge: Harvard University Press.

Klesges, R. C., Klesges, L. M., Eck, L. H., & Shelton, M. L. (1995). A longitudinal analysis of accelerated weight gain in preschool children. *Pediatrics, 95*(1), 126-130.

Knai, C., Pomerleau, J., Lock, K., & McKee, M. (2006). Getting children to eat more fruit and vegetables: a systematic review. *Prev Med, 42*(2), 85-95.

Kotecha, P. (2011). Nutritional anemia in young children with focus on Asia and India. *Indian J Community Med, 36*(1), 8-16.

Kovalskys, I., Rausch Herscovici, C., & De Gregorio, M. J. (2011). Nutritional status of school-aged children of Buenos Aires, Argentina: data using three references. *J Public Health (Oxf), 33*(3), 403-411.

Krølner, R., Rasmussen, M., Brug, J., Klepp, K. I., Wind, M., & Due, P. (2011). Determinants of fruit and vegetable consumption among children and adolescents: a review of the literature, part II: qualitative studies. *Int J Behav Nutr Phys Act, 8*(112), 2-38.

Kuczmarsk, R. J., Ogden, C. L., Guo, S. S., Grummer-Strawn, L. M., Flegal, K. M., Mei, Z., . . . Johnson, C. L. (2002). 2000 CDC growth charts for the United States: methods and development. *Vital Health Stat, 11*(246), 1-190.

Ledoux, T. A., Hingle, M. D., & Baranowski, T. (2011). Relationship of fruit and vegetable intake withadiposity: a systematic review. *Obes Rev, 12*(5), e143-e150.

Lioret, S., Touvier, M., Balin, M., Huybrechts, I., Dubuisson, C., Dufour, A., . . . Lafay, L. (2011). Characteristics of energy under-reporting in children and adolescents. *Br J Nutr, 105*(11), 1671-80.

Longo, D., Fauci, A., Kasper, D., Hauser, S., Jameson, J., & Loscalzo, J. (2011). *Harrison's principles of internal medicine* (18 ed. Vol. 1). New York: McGraw-Hill.

Lovendal, C. R., Jakobsen, K. T., & Jacque, A. (2007). Food prices and food security in Trinidad and Tobago, Rome. Retrieved Nov 15th, 2015 from: http://www.fao.org/3/a-ai134e.pdf

Malik, V. S., Schulze, M. B., & Hu, F. B. (2006). Intake of sugar-sweetened beverages and weight gain: a systematic review. *Am J Clin Nutr, 84*(2), 274-288.

Mark, S., Lambert, M., O'Loughlin, J., & Gray-Donald, K. (2012). Household income, food insecurity and nutrition in Canadian youth. *Can J Public Health, 103*(2), 94-99.

McLaren, L. (2007). Socioeconomic status and obesity. *Epidemiologic Reviews, 29*(1), 29-48.

McLean, E., Cogswell, M., Egli, I., Wojdyla, D., & de Benoist, B. (2009). Worldwide prevalence of anaemia, who vitamin and mineral nutrition information system, 1993-2005. *Public Health Nutr, 12*(4), 444-454.

Melgar-Quinonez, H. R., Zubieta, A. C., MkNelly, B., Nteziyaremye, A., Gerardo, M. F., & Dunford, C. (2006). Household food insecurity and food expenditure in Bolivia, Burkina Faso, And the Philippines. *J Nutr, 136*(5).

Metallinos-Katsaras, E., Must, A., & Gorman, K. (2012). A longitudinal study of food insecurity on obesity in preschool children. *J Acad Nutr Diet, 112*(12), 1949-1958.

Metcalf, B., Henley, W., & Wilkin, T. (2012). Effectiveness of intervention on physical activity of children: systematic review and meta-analysis of controlled trials with objectively measured outcomes (earlybird 54). *BMJ, 345* e5888-5811.

Metcalf, B. S., Hosking, J., Jeffery, A. N., Voss, L. D., Henley, W., & Wilkin, T. J. (2011). Fatness leads to inactivity, but inactivity does not lead to fatness: a longitudinal study in children (earlybird 45). *Arch Dis Child, 96*(10), 942-947.

Monson, E. R. (1988). Iron nutrition and absorption: dietary factors which impact iron bioavailability. *J Am Diet Assoc, 88*(7), 786-790.

Mora, J. O., Boy, E., Lutter, C., & Grajeda, R. (2009). *Anemia in Latin America and the Caribbean: situation snalysis trends, and implications for public health programming*. Washington, D.C.

Mosha, T. C., & Fungo, S. (2010). Prevalence of overweight and obesity among children aged 6-12 years in Dodoma and Kinondoni municipalities, Tanzania. *Tanzan J Health Res, 12*(1), 6-16.

Mujica-Coopman, M. F., Brito, A., López de Romaña, D., R´ıos-Castillo, I., Cori, H., & Olivares, M. (2015). Prevalence of anemia in Latin America and the Caribbean. *Food Nutr Bull, 36*(2), S119-128.

Murakami, K., Miyake, Y., Sasaki, S., Tanaka, K., & Arakawa, M. (2012). Characteristics of under- and over-reporters of energy intake among Japanese children and adolescents: the ryukyus child health study. *Nutrition, 28*(5), 532-538.

Murphy, S. P., & Johnson, R. K. (2003). The scientific basis of recent US guidance on sugars intake. *Am J Clin Nutr, 78*(4), 827S-834.

Must, A., & Anderson, S. E. (2006). Body mass index in children and adolescents: considerations for population-based applications. *Int J Obes (Lond), 30*(4), 590-594.

National Heart Lung and Blood Insititute. (2012a). What is anemia? Retrieved Sep 15th, 2015, from: https://www.nhlbi.nih.gov/health/health-topics/topics/anemia

National Heart Lung and Blood Insititute. (2012b). Who is at risk for sickle cell anemia? *sickle cell anemia.* Retrieved Sep 15th, 2015, from: http://www.nhlbi.nih.gov/health/health-topics/topics/sca/atrisk.html

Neufeld, L., García-Guerra, A., Sánchez-Francia, D., Newton-Sánchez, O., Ramírez-Villalobos, M. D., & Rivera-Dommarco, J. (2002). Hemoglobin measured by Hemocue and a reference method in venous and capillary blood: a validation study. *Salud Publica Mex, 44*(3), 219-227.

Newby, P. K., Peterson, K. E., Berkey, C. S., Leppert, J., Willett, W. C., & Colditz, G. A. (2003). Dietary composition and weight change among low-income preschool children. *Arch Pediatr Adolesc Med, 157*(8), 759-764.

Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., & Margono, C. (2013). Global, regional, and national prevalence of overweight and obesity in children and adults during

1980–2013: a systematic analysis for the global burden of disease study 2013. *Lancet, 384*(9945), 766-781.

Nielsen, S. J., & Popkin, B. M. (2004). Changes in beverage intake between 1977 and 2001. *Am J Prev Med, 27*(3), 205-210.

Nord, M. (2014). *Introduction to item response theory applied to food security measurement: basic concepts, parameters and statistic.* Retrieved Nov 21st, 2015, from: http://www.fao.org/3/a-i3946e.pdf

Nord, M., Andrews, M., & Carlson, S. (2005). *Household food security in the United States, 2005*. Washington, D.C. Retrieved Nov 21st, 2015, from: http://www.ers.usda.gov/media/860207/err29_002.pdf

Nord, M., & Hopwood, H. (2008). *A comparison of household food security in the United States.* Retrieved Nov 21st, 2015, from: http://www.ers.usda.gov/media/191355/err67.pdf

Ntwenya, J. E., Kinabo, J., Msuya, J., Mamiro, P., & Majili, Z. S. (2015). Dietary patterns and household food insecurity in rural populations of Kilosa district, Tanzania. *PLoS One, 10*(5), 1-13.

O'Loughlin, J., Gray-Donald, K., Paradis, G., & Meshefedjian, G. (2000). One- and two-year predictors of excess weight gain among elementary schoolchildren in multiethnic, low-income, inner-city neighborhoods. *Am J Epidemiol, 152*(8), 739-746.

Oski, F. A., Brugnara, C., & Nathan, D. G. (2003). *Adiagnostic approach to the anemic patient: Nathan and Oski's hematology of infancy and childhood* (Vol. 1). Philadelphia: Saunders.

PAHO. (1998). *Health in the Americas*. Washington, D. C. Retrieved Nov 21st, 2015, from: http://www1.paho.org/english/hia_1998ed.htm

Patel, A. J., Wesley, R., Leitman, S. F., Bryant, B. J. Capillary versus venous hemoglobin determination in the assessment of healthy blood donors. *Vox Sang, 104*(4): 317-323.

Parikka, S., Mäki, P., Levälahti, E., Lehtinen-Jacks, S., Martelin, T., & Laatikainen, T. (2015). Associations between parental BMI, socioeconomic factors, family structure and overweight in Finnish children: a path model approach. *BMC Public Health, 15*(1), 271.

Pasricha, S. R., Black, J., Muthayya, S., Shet, A., Bhat, V., Nagaraj, S., . . . Shet, A. S. (2010). Determinants of anemia among young children in rural India. *Pediatrics, 126*(1), 140-149.

Pérez-Escamilla, R., Melgar-Quiñonez, H., Nord, M., Alvarez Uribe, M. C., & Segall-Correa, A. M. (2007). Latinamerican and Caribbean food security scale. *Perspectivas en Nutrición Humana*, 117-134.

Pérez-Escamilla, R., & Segall-Correa, A. M. (2008). Food insecurity measurement and indicators. *Rev Nutr, 21*, 15s-26s.

Pettifor, J. M. (2014). Calcium and vitamin d metabolism in children in developing countries. *Ann Nutr Metab, 64*(2), 15-22.

Pinhas-Hamiel, O., Doron-Panush, N., Reichman, B., Nitzan-Kaluski, D., Shalitin, S., & Geva-Lerner, L. (2006). Obese children and adolescents: a risk group for low vitamin b12 concentration. *Arch Pediatr Adolesc Med, 160*(9), 933-936.

Plasqui, G., Bonomi, A. G., & Westerterp, K. R. (2013). Daily physical activity assessment with accelerometers: new insights and validation studies. *Obes Rev, 14*(6), 451-462.

Pollack, C., Chideya, S., Cubbin, C., Dekker, M., & Braveman, P. (2007). Should health studies measure wealth? a systematic review *Am J Prev Med, 33*(3), 250-264.

Pomerleau, J., Lock, K., McKee, M., & Altmann, D. (2004). The challenge of measuring global fruit and vegetable intake. *J Nutr, 134*(5), 6.

Poppitt, S. D., Swann, D., Black, A. E., & Prentice, A. M. (1998). Assessment of selective under-reporting of food intake by both obese and non-obese women in a metabolic facility. *Int J Obes Relat Metab Disord, 22*(4), 303-311.

Powell, A. D., & Kahn, A. S. (1995). Racial differences in women's desires to be thin. *Int J Eat Disord, 17*(2), 191-195.

Punch, F. P. (1998). *Introduction to social research: quantitative and qualitative approaches*. London: Sage.

Raben, A., Vasilaras, T. H., Møller, A. C., & Astrup, A. (2002). Sucrose compared with artificial sweeteners: Different effects on ad libitum food intake and body weight after 10 wk of supplementation in overweight subjects. *Am J Clin Nutr, 76*(4), 721-729.

Radimer, K. L., Olson, C. M., Greene, J. C., Campbell, C. C., & Habicht, J. P. (1992). Understanding hunger and developing indicators to assess it in women and children. *J Nutr Educ, 24*(1), 36S-44S.

Radimer, K. L., Oslon, C. M., & Campell, C. C. (1990). Development of indicators to assess hunger. *J Nutr, 120*, 1544-1548.

Ranasinghe, C., Gamage, P., Katulanda, P., Andraweera, N., Thilakarathne, S., & Tharanga, P. (2013). Relationship between body mass index (BMI) and body fat percentage, estimated by bioelectrical impedance, in a group of Sri Lankan adults: a cross sectional study. *BMC Public Health, 3*(13), 797.

Rangan, A. M., Flood, V. M., Denyer, G., Webb, K., Marks, G. B., & Gill, T. P. (2012). Dairy consumption and diet quality in a sample of Australian children. *J Am Coll Nutr, 31*(3), 9.

Reedy, J., & Krebs-Smith, S. M. (2010). Dietary sources of energy, solid fats and added sugars among children and adolescents in the United States. *J Am Diet Assoc, 110*(10), 1477-1484.

Roberts, P. (2006). Reliability and validity in research. *Nursing Standard, 20*(44), 41-45.

Romualdo, M. C., Nóbrega, F. J., & Escrivão, M. A. (2014). Insulin resistance in obese children and adolescents. *Jornal de pediatria, 90*(6), 600-606.

Sahn, D., & Stifel, D. (2000). Poverty comparisons over time and across countries in Africa. *World Development, 28*(12), 2123-2155.

Scharf, R. J., & DeBoer, M. D. (2015). Sleep timing and longitudinal weight gain in 4- and 5-year-old children. *Pediatr Obes, 10*(2), 141-148.

Schrager, S. (2005). Dietary calcium intake and obesity. *J Am Board Fam Pract, 18*(3), 205-210.

Serdula, M. K., Ivery, D., Coates, R. J., Freedman, D. S., Williamson, D. F., & Byers, T. (1993). Do obese children become obese adults? a review of the literature. *Prev Med, 22*(2), 167-177.

Shalitin, S., Abrahami, M., Lilos, P., & Phillip, M. (2005). Insulin resistance and impaired glucose tolerance in obese children and adolescents referred to a tertiary-care center in Israel. *Int J Obes (Lond), 29*(6), 571-578.

Sharif, M. R., Madani, M., & Tabatabaie, F. (2014). Comparative evaluation of iron deficiency among obese and non-obese children. *Iran J Ped Hematol Oncol, 4*(4), 160-166.

Sherraden, M. (1991). *Assets and the poor, a new American welfare policy.* Armonk, NY: M.E. Sharpe.

Sichert-Hellert, W., Kersting, M., & Schöch, G. (1998). Underreporting of energy intake in 1 to 18 year old German children and adolescents. *Z Ernahrungswiss, 37*(3), 242-51.

Siegenberg, D., Baynes, R. D., Bothwell, T. H., Macfarlane, B. J., Lamparelli, R. D., Car, N. G., . . . Mayet, F. (1991). Ascorbic acid prevents the dose-dependent inhibitory effects of polyphenols and phytates on nonheme-iron absorption. *Am J Clin Nutr, 53*(2), 537-541.

Simmons, W. K. (1994). Control of iron and other micronutrients deficiencies in the English-speaking Caribbean. *Bull Pan Am Health Organ, 28*(4), 10.

Simmons, W. K., & Gurney, J. M. (1982). Nutritional anemia in the English-speaking Caribbean and Suriname. *Am J Clin Nutr, 35*(2), 327-337.

Skalicky, A., Meyers, A. F., Adams, W. G., Yang, Z., Cook, J. T., & Frank, D. A. (2006). Child food insecurity and iron deficiency anemia in low-income infants and toddlers in the United States. *Matern Child Health J, 10*(2), 177-185.

Sorof, J., & Daniels, S. (2002). Obesity hypertension in children: a problem of epidemic proportions. *Hypertension, 40*(4), 441-447.

Statistics Canada. (2015). *Health at a glance, food insecurity in Canada*. (82-624-X). Retrieved Oct 10th, 2015, from: http://www.statcan.gc.ca/pub/82-624-x/2015001/article/14138-eng.pdf.

Subar, A. F., Freedman, L. S., Tooze, J. A., Kirkpatrick, S. I., Boushey, C., Neuhouser, M. L., . . . Krebs-Smith, S. M. (2015). Addressing current criticism regarding the value of self-report dietary data. *J Nutr, 145*(12), 2639-2645.

Subar, A. F., Kipnis, V., Troiano, R. P., Midthune, D., Schoeller, D. A., Bingham, S., . . . Schatzkin, A. (2003). Using intake biomarkers to evaluate the extent of dietary misreporting in a large sample of adults: the OPEN study. *Am J Epidemiol, 158*(1), 1-13s.

Tanner, J. M. (1965). *The relationship of puberty to other maturity indicators and body composition in man*. Paper presented at the Symposia of the Society for the Study of Human Biology.

Tapiero, H., Gate, L., & Tew, K. D. (2001). Iron: deficiencies and requirements. *Biomed Pharmacother, 55*(6), 324-332.

Tarasuk, V. (2002). *Discussion paper on household and individual food insecurity*. Retrieved April 5th, 2016, from: http://www.hc-sc.gc.ca/fn-an/nutrition/pol/food_sec_entire-sec_aliments_entier-eng.php

Tarasuk, V., & Maclean, H. (1990). The food problems of low-income single mothers: an ethnographic study. *Can Home Econ, 40*, 76-82.

Timpson, N. J., Emmett, P. M., Frayling, T. M., Rogers, I., Hattersley, A. T., McCarthy, M. I., & Davey Smith, G. (2008). The fat mass- and obesity-associated locus and dietary intake in children. *Am J Clin Nutr, 88*(4), 971-978.

Travers, K. (1996). The social organization of nutritional inequities. *Soc Sci Med, 43, 543-553.*

Trumbo, P., Yates, A. A., Schlicker, S., & Poos, M. (2001). Dietary reference intakes for vitamin a, vitamin k, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. *J Am Diet Assoc*.

Tuomainen, T. P., Nyyssonen, K., Salonen, R., Tervahauta, A., Korpela, H., Lakka, T., … Salonen, J. T. (1997). Body iron stores are associated with serum insulin and blood glucose concentration: population study in 1,013 eastern Finnish men. *Diabetes Care, 20*(3), 426-428.

UN. (2002). *Human development report 2002, deepening democracy in a fragmented world*. New York: Retrieved Nov 13th, 2015, from: http://hdr.undp.org/sites/default/files/reports/263/hdr_2002_en_complete.pdf

UNICEF. (2013a). Brazil, statistics, nutrition. Retrieved Nov 12th, 2015, from http://www.unicef.org/infobycountry/brazil_statistics.html

UNICEF. (2013b). Colombia, statistics, nutrition. Retrieved Nov 3rd, 2015, from: http://www.unicef.org/infobycountry/colombia_statistics.html

UNICEF. (2013c). Tanzania, United Republic of, statistics, nutrition. Retrieved Nov 3rd, 2015, from: http://www.unicef.org/infobycountry/tanzania_statistics.html

United States Department of the Air Force, & United States Department of the Army. (1973). Methods in hematology. *Clinical laboratory procedure-hematology*. Washington, D.C.

USDA. (2010). Foods and food components to reduce dietary guidelines for Americans (pp. 20-32). Washington, D.C.

USDA. (2012). U.S. household food security survey module: three-stage design, with screeners. *Economic Research Service.* Retrieved Oct 15th, 2015, from: http://www.ers.usda.gov/datafiles/Food_Security_in_the_United_States/Food_Security_Survey_Modules/hh2012.pdf

USDA. (2015). Food security in the U.S., key statistics and graphics. Retrieved Nov 21st, 2015, from: http://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/key-statistics-graphics.aspx

Valberg, L. S. (1980). Plasma ferritin concentration: their clinical significance and relevance to patient care. *Can Med Assoc, 122*(11), 1240-1248.

Von Schenck, H., Falkensson, M., & Lundberg, B. (1986). Evaluation of "HemoCue" a new device for determining hemoglobin. *Clin Chem, 32*(3), 526-529.

Walter, T., Olivares, M., Pizarro, F., & Muñoz, C. (1997). Iron, anemia, and infection. *Nutr Rev, 55*(4), 111-124.

Wang, Y., Ge, K., & Popkin, B. M. (2003). Why do some overweight childrenremain overweight, whereas others do not? *Public Health Nutr, 6*(6), 549-558.

Welk, G. J., Corbin, C. B., & Dale, D. (2000). Measurement issues in the assessment of physical activity in children. *Res Q Exerc Sport, 71*(2), S59-73.

Whitaker, R. C., Wright, J. A., Pepe, M. S., Seidel, K. D., & Dietz, W. H. (1997). Predicting obesity in young adulthood from childhood and parental obesity. *N Engl J Med, 337*(13), 869-873.

WHO. (1995). *Physical status: the use and interpretation of anthropometry* (854). Geneva: Retrieved Nov 21st, 2015, from: http://apps.who.int/iris/handle/10665/37003

WHO. (2001). Iron deficiency anaemia: assessment, prevention, and control: a guide for programme managers. Retrieved Nov 7th, 2015, from: http://www.who.int/nutrition/publications/micronutrients/anaemia_iron_deficiency/WHO_NHD_01.3/en/

WHO. (2005). World health statistics 2005. Retrieved Nov 5th, 2015, from: http://www.who.int/whosis/whostat/2005/en/

WHO. (2006). WHO child growth standards, backgrounder 4, what is the double burden of malnutrition? Retrieved Nov 21st, 2015, from: http://www.who.int/childgrowth/4_double_burden.pdf

WHO. (2013a). Micronutrient deficiencies, iron deficiency anaemia. Retrieved Aug 20th, 2015, from: http://www.who.int/nutrition/topics/ida/en/

WHO. (2013b). Micronutrients. Retrieved from http://www.who.int/nutrition/topics/micronutrients/en/index.html

WHO. (2013c). Obesity and overweight: Fact sheet. Retrieved March 8th, 2013, from: http://www.who.int/mediacentre/factsheets/fs311/en/

WHO. (2015a). Food security, trade, foreign policy, diplomacy and health. Retrieved Aug 20th, 2015, from: http://www.who.int/trade/glossary/story028/en/

WHO. (2015b). Global database on child growth and malnutrition. Retrieved Nov 19th, 2015, from: http://www.who.int/nutgrowthdb/about/introduction/en/index5.html

WHO. (2015c). Global strategy on diet, physical activity and health, physical activity and young people. Retrieved Nov 21st, 2015, from: http://www.who.int/dietphysicalactivity/factsheet_young_people/en/

WHO. (2015d). Growth reference 5-19 years, height-for-age (5-19 years). Retrieved May 20th, 2015, from: http://www.who.int/growthref/en/

WHO. (2015e). Nutrition, challenges. Retrieved Aug 27th, 2015, from: http://www.who.int/nutrition/challenges/en/

WHO. (2015f). Nutrition, challenges. Retrieved May 26th, 2016, from: http://www.who.int/mediacentre/news/releases/2015/sugar-guideline/en/

WHO, & CDC. (2008). Worldwide prevelence of anaemia 1993-2005: WHO global database on anaemia. Retrieved Sep 13th, 2015, from: http://apps.who.int/iris/bitstream/10665/43894/1/9789241596657_eng.pdf

WHO, & FAO. (2002). *Diet, nutrition and the prevention of chronic diseases, report of a joint WHO/FAO expert consultation*. Geneva. Retrieved Nov 13th, 2015, from: ftp://ftp.fao.org/docrep/fao/005/ac911e/ac911e00.pdf

WHO Europe. (2004). *Young people's health in context, health behaviour in school-aged children (HBSC) study: international report from the 2001/2002 survey*. Copenhagen. Retrieved Oct 15th, 2015, from: http://www.who.int/immunization/hpv/target/young_peoples_health_in_context_who_2011_2012.pdf

WHO., UNICEF., & UNU. (2001). Iron deficiency anaemia: assessment, prevention and control, a guide for programme mangers. Geneva. Retrieved Dec 1st, 2015, from: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html

Widhalm, K., Schönegger, K., Huemer, C., & Auterith, A. (2001). Does the BMI reflect body fat in obese children and adolescents? a study using the TOBEC method. *Int J Obes Relat Metab Disord, 25*(2), 279-285.

Willett, W. (2012). *Nutritional epidemiology* (3rd ed. Vol. 40). New York: Oxford University Press.

Winkleby, M. A., Jatulis, D. E., Frank, E., & Fortmann, S. P. (1992). Socioeconomic statusand health: how education,income,and occupation contribute to risk factors for cardiovascular disease. *Am J Public Health, 82*(6), 816-820.

World Bank. (2003). Measuring living standards: household consumption and wealth indices, quantitative techniques for health equity analysis-technical note#4. Retrieved Aug 21st, 2015, from: http://siteresources.worldbank.org/INTPAH/Resources/Publications/Quantitative-Techniques/health_eq_tn04.pdf

Wrotniak, B. H., Epstein, L. H., Paluch, R. A., & Roemmich, J. N. (2004). Parent weight change as a predictor of child weight change in family-based behavioral obesity treatment. *Arch Pediatr Adolesc Med, 158*(4), 342-347.

Xuereb, G., Johnson, P., Morris, A., Bocage, C., Trotter, P., & Henry, F. (2001). Obesity in Caribbean children: its magnitude and current control efforts. *CAJANUS, 34*(3), 120-126.

Zwiauer, K., Widhalm, K., & Kerbl, B. (1990). Relationship between body fat distribution and blood lipids in obese adolescents. *Int J Obes, 14*(3), 271-277.

CHAPTER III. FOOD INSECURITY LINKED TO DIET BUT NOT GROWTH OF CHILDREN IN THE CARIBBEAN

Authors

1. Walaa A. Mumena, Ph.D. Candidate, School of Dietetics and Human Nutrition, McGill University, Sainte-Anne-de-Bellevue, Québec, Canada
2. Isabella Francis-Granderson, Principle Investigator of the CARICOM food security project, Faculty of Food and Agriculture, University of the West Indies, St. Augustine Campus, Trinidad and Tobago
3. Leroy E. Phillip, Principle Investigator of the CARICOM food security project, Department of Animal Science, McGill University, Sainte-Anne-de-Bellevue, Québec, Canada
4. Louise Johnson-Down, MSc, School of Dietetics and Human Nutrition, McGill University, Sainte-Anne-de-Bellevue, Québec, Canada
5. Katherine Gray-Donald, School of Dietetics and Human Nutrition, McGill University, Sainte-Anne-de-Bellevue, Québec, Canada

3.1. Abstract

Background: Food security is linked to diet and growth of children in a number of settings, but the link is not clear in upper-income developing countries. This study aimed to examine food insecurity and it is relationship with children's nutritional health.

Methods: Data for 390 children aged 6-10 years and their caregivers, recruited from eight schools in Trinidad and seven schools in St. Kitts in 2013-14 for a study of school meals were examined to address the link between food security and nutritional indicators. Food security status, evaluated using the USDA's Household Food Security Survey Module, and 24-hour dietary intake of children were measured in home interviews. Height and weight were measured and a capillary blood sample was collected at school.

Results: The Household Food Security Survey Module of the USDA found to be valid to use among this study population. Overall, 42% of caregivers reported household food insecurity, with 15% of the children living in households with very low food security. Daily intakes of protein and zinc were significantly higher among children from "food secure" versus "food insecure" households (protein, 59.6 ± 31.5 g vs. 50.9 ± 24.4 g, p=0.003; zinc, 7.33 ± 5.02 mg vs. 6.20 ± 3.47 mg, p=0.004, respectively). There was no difference in other micronutrient or energy intakes between the two study groups, nor any difference in the consumption of food portions of meat, milk, fruits and vegetables. Children living in households with very low food security did not consume fewer quantities of any nutrient as compared to children living in household with low food security. Children's BMI z-score, weight status (overweight/obese vs. healthy weight) and HFA z-score were not associated with household food insecurity, and there was no evidence of stunting in either group. Anemia, however, was prevalent (30%) particularly among children from food insecure households (39% vs. 23%; p=0.002).

Conclusion: Household food insecurity status was reflected in some lower nutrient intakes and anemia rates were higher among children living in food insecure households but food insecurity was not related to any indicators of growth or weight status.

3.2. Introduction

The World Food Summit of 1996 defined food security as existing “when all people at all times have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active, healthy life” (FAO, 1996). Despite efforts to improve global food security, there remain important challenges in addressing the problem. Substantial strides have been made in reducing child underweight, but this has been uneven globally and few indicators of food insecurity and undernourishment have been tracked at the household level (FAO, 2015). In the Caribbean, there is substantial concern about food insecurity with few indicators available on how this may be affecting children.

The association between food insecurity and dietary intake is less widely studied. In North America, food insecurity among children and youth has been linked to low intakes of fruits and vegetables (Kendall, Olson, & Frongillo, 1996), dietary inadequacy for calcium (Kirkpatrick et al., 2015) and protein (Kirkpatrick & Tarasuk, 2008), and lower intakes of vitamin D (Mark, Lambert, O'Loughlin, & Gray-Donald, 2012). Food insecurity has also been shown to affect children’s dietary intake differently than adults, as mothers often protect children from the effects of food insecurity, and especially from the effects of severe food insecurity (Kirkpatrick & Tarasuk, 2008; Nord & Hopwood, 2008). In low-income developing countries, food insecurity has been related to food diversity, but data regarding children’s dietary intakes in relation to food security status are lacking in most developing countries.

The link between food insecurity and children’s nutritional status is not well understood. In a number of developing countries where stunting, wasting and underweight are prevalent, such as Colombia (UNICEF, 2013a), Pakistan (UNICEF, 2013b) and Tanzania (UNICEF, 2013c), food insecurity has been associated with stunting and underweight among children

(Cesare et al., 2015; Cordeiro, Wilde, Semu, & Levinson, 2012; Hackett, Melgar-Quinonez, & Alvarez, 2009; Isanaka, Mora-Plazas, Lopez-Arana, Baylin, & Villamor, 2007). Studies conducted in North America reveal no such associations (Bhattacharya, Currie, & Haider, 2004; Gundersen, Lohman, Eisenmann, Garasky, & Stewart, 2008). A relationship between food insecurity and weight gain as well as obesity has been found in some studies (Jyoti, Frongillo, & Jones, 2005), but stronger evidence suggests no association between these variables (Bhargava, Jolliffe, & Howard, 2008; Bhattacharya, Currie, & Haider, 2004; Eisenmann, Gundersen, Lohman, Garasky, & Stewart, 2011). An association between food insecurity and anemia (with and without iron deficiency) among young children and adolescents has been documented in both developed and developing settings (Campbell et al., 2011; Eicher-Miller, Mason, Weaver, McCabe, & Boushey, 2009; Skalicky et al., 2006).

Among Caribbean children, underweight has declined and childhood obesity has become increasingly prevalent causing a serious concern for the burden of non-communicable diseases (PAHO, 1997; Popkin, Adair, & Ng, 2012; Schwiebbe et al., 2011; Xuereb et al., 2001). While food availability data indicate an overabundance of energy, sugars and fats, and limited amounts of milk, fruits and vegetables (Ballayram & Henry, 2008; CFNI, 2007), there is no information concerning how food insecure children are faring in relation to dietary intake, growth and anemia. Our aim in this study was to examine the association between food insecurity and dietary intake, linear growth, weight status and anemia of children in two upper-income developing countries in the Caribbean.

3.3. Methods

The study was part of a broader multidisciplinary project dealing with food and nutrition security, with a focus on interventions with local farmers and school feeding programs to improve nutritional outcomes of children in the Caribbean Community (CARICOM); aspects of the project have been previously reported (Phillip & Francis-Granderson, 2014).

Data for this study were collected between September 2013 and April 2014. Children aged 7-12 years and their caregivers were recruited from eight schools in Trinidad and Tobago and seven schools in St. Kitts and Nevis. In Trinidad, schools selected were those with a high proportion of children consuming the school lunch meals, which are offered to families in need. Schools in St. Kitts, where all children are offered a free lunch, were selected from rural areas near the capital. For families with more than one child in the eligible age range, the child under study was randomly chosen.

All measures were collected at two time points, a baseline and a follow-up survey, but only the follow-up survey data were used in this study, as a more comprehensive measure of food security was used at this time. Half of the children were in schools with an intervention which marginally increased fruit and vegetable consumption, but food security status was not related to whether or not schools received the intervention.

Child's height was measured as a standing height using a stadiometer and body weight was measured with a digital floor scale. Height and weight were used to determine children's BMI z-score by the standards of the World Health Organization (WHO). A finger prick blood test was collected by a project nurse to measure hemoglobin level from a capillary sample by HemoCue. These measures were collected at school.

At a home visit a single 24-hour dietary recall for the child was collected by trained interviewers. Caregivers and their children were asked to recall in detail the types and amounts of foods consumed by the child on the previous day. Portion models (Santé Quebec, Montreal, Canada) were provided to assist in estimating the amounts consumed in fluid measures; values for each food item were transformed to grams for the purpose of data entry and processing. Dietary data were compiled using CANDAT Nutrient Analysis Software (Godin London Incorporated, London, ON), which provides a nutrient analysis based on the Canadian Nutrient Files (2010 version) (Health Canada, 2007b). Most processed foods were imported and where these were locally produced, food labels or local recipes were added to the database. Foods were grouped based on the Six Caribbean Food Groups (staples, legumes and nuts, foods from animals, fruits, vegetables, fats and oils) (Zephirin & Manuelita, 1990). Further division of these food groups was undertaken to measure milk and milk products as well as “ground provisions” which included green banana, plantain, breadfruit, corn, sweet potato and cassava. Serving sizes for ground provisions were calculated based on average carbohydrate content in one serving of grain products. Portions of milk and milk products followed Canada’s Food Guide (CFG) portion sizes (Health Canada, 2007c). Vitamin and mineral supplements taken on the day of the 24-hour dietary recall were included in the nutrient intake values.

In addition, at the home visit an interviewer administered questionnaire was done with the primary caregiver of the child. The questionnaire provided demographic information and food security data. The food security status was assessed using the 18-item U.S. Household Food Security Survey Module of the USDA to classify adult and child food security status as well as that of the household (USDA, 2012). This measure was previously validated for use in the Caribbean (Gulliford, Nunes, & Rocke, 2006). The Rasch model was used to assess the internal validity of the 18-item U.S. Household Food Security Survey Module of the USDA in this setting. Height and weight of caregivers were also measured during this home visit.

3.4. Statistical analysis

The Household Food Security Survey Module of the USDA was validated using the Rasch model. This model assessed the relative severity of all items as well as the item-fit statistics (item infit and item outfit). Expected values for both statistics are equal to 1.0 and values >1.0 indicate poorer fit, while values <1.0 indicate that items are more strongly related to food insecurity than the average items. Acceptable infits are between 0.7 and 1.3 and because item-outfit is very sensitive to outliers, values are not very important to consider during the validation process (Nord, 2014). Household food security status was categorized according to USDA procedures as high (raw score of zero), marginal (raw score 1-2), low (raw score of 3-7) and very low food security (raw score > 8). As recommended by the USDA, high and marginal food security levels were combined to construct a “food secure” group, and low and very low levels of food security were combined as a “food insecure” group. In addition, child-specific food security status as measured by questions specifically related to the child’s experiences was categorized as high or marginal (raw score 0-1), low (raw score 2-4), or very low food security (raw score > 5) (USDA, 2012).

WHO cut-off points were used to define caregivers weight status which are: thinness <18.5 kg/m^2, healthy weight 18.5-24.9 kg/m^2, overweight 25-29.9 kg/m^2, obesity ≥30 kg/m^2 (WHO, 2015). The WHO BMI z-score cut-off points for children (severe thinness, < −3SD; thinness, < −2SD; overweight, >1SD; and obesity, >2SD) (WHO, 2013) were used for interpretation of children’s weight status. The WHO cut-off point for height-for-age z-score (HFA z-score) < −2 was used to assess stunting. The WHO cut-off points for hemoglobin level to identify anemia among children aged 5-11 years are <11.5 g/dL and <12.0 g/dL for children aged 12 years (WHO & CDC, 2008). However, race-specific cut-offs were used in this study to diagnose anemia among individuals of African descent, with a cut-off 1 g/dL lower (10.5 g/dL and 11.0 g/dL for children aged 5-11years and 12 years, respectively) as recommended by the WHO/UNICEF/UNU (Gibson, 2005; Johnson-Spear & Yip, 1994).

Descriptive data for characteristics of children and their caregivers are presented as means and standard deviations, and categorical variables are presented as percentages. Log and square root functions were used to normalize the data where needed. T-tests and analysis of variance (ANOVA) were used to compare the means of the various groups and Chi-squared tests were used to compare proportions. Statistical tests were 2-tailed, and a significance level of $p < 0.05$ was established; Tukey's pairwise comparisons were undertaken to test associations of food insecurity and dietary intake. Statistical analysis was performed using SAS® software version 9.3 (2011, SAS Institute Inc., Cary, NC, USA).

3.5. Results

A total of 390 children and their caregivers, 232 from Trinidad and 158 from St. Kitts, were included in this study after excluding 7.0% (n=26) of the children with very high (> 4000 kcal) 1.2% (n=5) for very low energy intakes (< 700 kcal), 3.2% (n=13) and 5.6% (n=23) with missing food security and dietary intake data, respectively. Hemoglobin data were available for only 331 children.

Based on the main assumptions in the Rasch model (relative severity and item-fit statistics), the 18-item U.S. Household Food Security Survey Module of the USDA found to be valid. Items, relative severity and item-fit statistics are provided in the **Supplementary Table 1**. According to responses to the 18-item U.S. Household Food Security Survey Module, 42% of households reported being food insecure with higher prevalence in Trinidad compared to St. Kitts (46% vs. 35%, p=0.044). Twenty six percent (n=103) of children were living in households with low food security, while15% (n=59) of children were living in households with very low food security. Child-specific food insecurity showed a similar pattern with an overall prevalence of 27%, higher in Trinidad than in St. Kitts (32% vs. 20%; p=0.012). Demographic variables by household food security status, are shown in **Table 1**. There were no differences in the age or sex of children between food secure and food insecure households. The caregivers were predominantly female (94%), with no difference in gender representation between the two food security groups. The level of education of caregivers as well as household size were also similar across both food security groups. Caregivers in food insecure households were significantly younger (p =0.036) and more likely to be unmarried (p=0.023) than those in food secure households.

Dietary intakes of children living in households with very low food security were not lower than dietary intake of children who were living in households with low food security. Thus, only the dietary intake of children from food secure and food insecure households are provided in **Table 2.** In general, mean daily intakes (by portions) of milk and milk products, fruits and vegetables were low as compared to the recommendations of the CFG (Health Canada, 2007a) and the WHO/FAO (WHO & FAO, 2002). Lower intakes of protein and zinc were reported among children from food insecure households. There were no other differences in macro or micronutrients intakes. Mean protein intake for children from food secure and food insecure households contributed 14% and 12%, respectively, of the total energy intake; which falls within the acceptable macronutrient distribution range (10-30%) of the Dietary Reference Intake (DRI) values for children of this age (Institute of Medicine Food and Nutrition Board, 2005). Mean protein intake for children from food insecure households was 1.46 g/kg body weight vs. 1.69 g/kg body weight for children from food secure households. Intakes of staples, ground provisions, milk, meat, legumes, fruits and vegetables were similar among food secure and food insecure groups.

A separate analysis was undertaken to assess child-specific food security status as opposed to household food security. When comparing highly and marginally food secure children (n=282) to children with a low (n=80) or very low level of food security (n=26), no differences were observed in dietary intakes among the three food security groups.

Anthropometric measurements of children living in households with low food security and very low food security were similar, so only anthropometric measurement of children living in food secure and food insecure households are presented in **Table 3.** There were no differences in HFA z-scores of children from food secure and insecure households and both groups had mean values above the mean height-for-age of the WHO reference values. Stunting was rare among children and there was no difference among children from food secure and food insecure households. Thinness (low height-for-weight < −2 SD) showed no differences between children from both food secure and food insecure households. The percentage of overweight or obese children was similar between those from food secure versus food insecure households. No associations were found when we examined the relationship between food security and measures of height and weight of among children using the child-specific measure of food security rather than the household measure. Thirty percent of children included in this study were anemic. More anemic children were living in food insecure households and means of hemoglobin levels for both groups were also different (**Table 4)**. For children living in very low food secure households, anemia was not higher than the prevalence among children who were living in low food secure households. In addition, the hemoglobin levels of children living in very low food secure households were not different from the hemoglobin levels of children living in low or marginal food secure households.

3.6. Discussion

Despite the high prevalence of food insecurity at the household level and also among children, no association was found between household food insecurity and children's growth or weight status. In this study, children are growing well, as the mean height for both groups were well above the mean of the WHO growth reference (mean HFA has a z-score of 0). The lack of association between food insecurity and children's growth is consistent with findings of a study from Brazil (Cordeiro, Monego, & Martins, 2014), where stunting was not prevalent (1.3%), but contrasts with results from Columbia (Hackett, Melgar-Quinonez, & Alvarez, 2009; Isanaka, Mora-Plazas, Lopez-Arana, Baylin, & Villamor, 2007) and Tanzania (Cordeiro et al., 2012), countries with high prevalence of stunting and/or underweight (UNICEF, 2013a, 2013c). Although there was a tendency for more children to appear to be stunted in the food insecure group, 2.5% of the is expected in a healthy population due to natural variations in height (Gibson, 2005). The prevalence of obesity was not related to food insecurity as has been shown in a number of American studies (Bhattacharya, Currie, & Haider, 2004; Gundersen, Lohman, Eisenmann, Garasky, & Stewart, 2008). It would seem that while a substantial proportion of families are food insecure in the Caribbean, food insecurity is not related to linear growth or weight status.

Dietary intakes were similar between of children from food secure and food insecure households, but lower intakes of protein and zinc were observed among children from food insecure households. These findings may reflect lower meat consumption among this group, which we could not identify from a single day's intake. Lower meat intakes among children and meat supplies in food insecure households were reported by studies in the U.S. (Matheson, Varady, Varady, & Killen, 2002) and Ecuador (Hackett, Zubieta, Hernandez, & Melgar-Quiñonez, 2007). Protein intakes of children in our study are unlikely to be a serious nutritional concern, as the mean intake of protein was double the Estimated Average Requirement (EAR) (protein 0.76 g/kg/d for children aged 4-13) for even those in the food insecure group (Institute of Medicine, 2001; Institute of Medicine, 2005). However, average zinc intake of children from food insecure household was below the EAR of 7 mg/d. It is important to assess zinc status among children, as zinc is crucial trace element that is required for children's growth and cognitive development (Black, 1998). In addition to assessing dietary intake of zinc, the use of biochemical indices of zinc status is recommended (Institute of Medicine, 2001).

Mean dietary iron intake of children in this study was not low and did not differ by food security status. The form of iron, heme vs. non-heme, which affects the efficiency of iron absorption, may influence the relationship between food insecurity and anemia. The relationship between food insecurity and anemia found in this study is in line with findings in the U.S. (Skalicky et al., 2006) and Indonesia (Campbell et al., 2011) among young children (< 5 y), as well as among American adolescents (Eicher-Miller, Mason, Weaver, McCabe, & Boushey, 2009).

In developed countries, such as the U.S. and Canada, studies have reported lower intakes of fruits and vegetables, as well as milk among children from food insecure households (Dave, Evans, Saunders, Watkins, & Pfeiffer, 2009; Kendall, Olson, & Frongillo, 1996; Mark, Lambert, O'Loughlin, & Gray-Donald, 2012). In our study, there was no association between food insecurity and fruit and vegetable intakes. This lack of association might be due to the very low intakes of fruit and vegetable among the entire population. A study among American Hispanic children aged 5-12 years also found no association between food insecurity and fruit and vegetables intake, and low mean intake of fruit and vegetable was observed among all children (Dave, Evans, Saunders, Watkins, & Pfeiffer, 2009).

This study is the first study to investigate the problem of food insecurity in relation to dietary intake, growth, weight status and anemia among children the Caribbean. Also, this study highlights the dietary patterns of children in the region, which was not investigated previously. In addition, current data regarding anemia among school-aged children in the region has not been examined.

One cannot generalize the rates of food insecurity found in this study to national levels. In the sample from Trinidad, the schools selected were those with a high proportion of children receiving the free lunch, which is offered on the basis of need. The links made between food security and nutritional indicators, however, can be clearly made within this high-risk group. Dietary assessment was done using a 24-hour dietary recall to obtain quantitative data on dietary intake. As only one recall was collected, we could not account for within-person variation and use appropriate methodologies to estimate the proportion of children whose usual intake was below their needs for any of the nutrients. However, a single day of well-conducted 24-dietary recall for a large group provides estimate of group average intake (Beaton et al., 1979).

In conclusion, there is no evidence to suggest that children's growth and weight status are affected by food insecurity, but diet quality of children is affected and may be linked to anemia and less apparent differences in nutritional status. There is a need to examine anemia with more comprehensive measures to better understand this phenomenon in school-aged children.

3.7. References

Ballayram., & Henry, F. (2008). Food and nutrition security in CARIFORUM countries. *CAJANUS, 4*.

Beaton, G. H., Milner, J., Corey, P., McGuire, V., Cousins, M., Stewart, E., . . . Little, J. A. (1979). Sources of variance in 24-hour dietary recall data: implications for nutrition study design and interpretation. *Am J Clin Nutr, 32*(12), 2546-2559.

Bhargava, A., Jolliffe, D., & Howard, L. L. (2008). Socio-Economic, behavioural and environmental factors predicted body weights and household food insecurity scores in the early childhood longitudinal study-kindergarten. *Br J Nutr, 100*(2), 438-444.

Bhattacharya, J., Currie, J., & Haider, S. (2004). Poverty, food insecurity, and nutritional outcomes in children and adults. *J Health Econ, 23*(4), 839-862.

Black, M. M. (1998). Zinc deficiency and child development. *Am J Clin Nutr, 68*(2 Suppl), 464S-469S.

Campbell, A. A., Akhter, N., Sun, K., De Pee, S., Kraemer, K., Moench-Pfanner, R., . . . Semba, R. D. (2011). Relationship of household food insecurity to anaemia in children aged 6-59 months among families in rural Indonesia. *Ann Trop Paediatr, 31*(4), 321-330.

Cesare, M. D., Bhatti, Z., Soofi , S. B., Fortunato, L., Ezzati, M., & Bhutta, Z. A. (2015). Geographical and socioeconomic inequalities in women and children's nutritional status in Pakistan in 2011: an analysis of data from a nationally representative survey. *Lancet Glob Health, 3*(4), e229-239.

CFNI. (2007). *Vulnerability and food and nutrition security in the Caribbean*. Retrieved Nov 15th from: http://s3.amazonaws.com/zanran_storage/www.euacpcommodities.eu/ContentPages/2465803400.pdf

Cordeiro, L. S., Wilde, P. E., Semu, H., & Levinson, F. J. (2012). Household food security is inversely associated with undernutrition among adolescents from Kilosa, Tanzania. *J Nutr, 142*(9), 1741-1747.

Cordeiro, M. M., Monego, E. T., & Martins, K. A. (2014). Overweight in Goiás'quilombola students and food insecurity in their families. *SciELO, 27*(4), 405-412.

Dave, J. M., Evans, A. E., Saunders, R. P., Watkins, K. W., & Pfeiffer, K. A. (2009). Associations among food insecurity, acculturation, demographic factors, and fruit and vegetable intake at home in Hispanic children. *J Am Diet Assoc, 109*(4), 697-701.

Eicher-Miller, H. A., Mason, A. C., Weaver, C. M., McCabe, G. P., & Boushey, C. J. (2009). Food insecurity is associated with iron deficiency anemia in US adolescents. *Am J Clin Nutr, 90*(5), 1358-1371.

Eisenmann, J. C., Gundersen, C., Lohman, B. J., Garasky, S., & Stewart, S. D. (2011). Is food insecurity related to overweight and obesity in children and adolescents? a summary of studies,1995–2009. *Obes Rev, 12*(5), e73-e83.

FAO. (1996). *Rome declaration on world food security and world and world food summit plan of action.* Retrieved Nov 21st, 2014, from: http://www.fao.org/docrep/003/w3613e/w3613e00.HTM

FAO, & WFP. (2015). *The state of food insecurity in the world 2015*, *meeting the 2015 international hunger targets: taking stock of uneven progress,* Rome. Retrieved Nov 21st, 2015, from: http://www.fao.org/3/a-i4646e.pdf

Gibson, R. S. (2005). *Principles of nutritional assessment* (2nd ed.). New York: Oxford University Press.

Gulliford, M. C., Mahabir, D., Rocke, B., Chinn, S., & Rona, R. J. (2002). Free school meals and children's social and nutritional status in Trinidad and Tobago. *Public Health Nutr, 5*(5), 625-630.

Gulliford, M. C., Nunes, C., & Rocke, B. (2006). The 18 household food security survey items provide valid food security classifications for adults and children in the Caribbean. *BMC Public Health, 6*(26).

Gundersen, C., Lohman, B. J., Eisenmann, J. C., Garasky, S., & Stewart, S. D. (2008). Child-specific food insecurity and overweight are not associated in a sample of 10- to 15-year-old low-income youth. *J Nutr, 138*(2), 371-378.

Hackett, M., Melgar-Quinonez, H., & Alvarez, M. C. (2009). Household food insecurity associated with stunting and underweight among preschool children in Antioquia, Colombia. *Rev Panam Salud Publica, 25*(6), 506-510.

Hackett, M., Zubieta, A. C., Hernandez, K., & Melgar-Quiñonez, H. (2007). Food insecurity and household food supplies in rural Ecuador. *Arch Latinoam Nutr, 57*(1), 10-17.

Health Canada. (2007a). Food and nutrition, Canada's food guide. Retrieved Oct 6th, 2015, from: http://www.hc-sc.gc.ca/fn-an/food-guide-aliment/basics-base/quantit-eng.php

Health Canada. (2007b). Food and nutrition, the Canadian nutrient file. Retrieved Oct 6th, 2015, from: http://www.hc-sc.gc.ca/fn-an/nutrition/fiche-nutri-data/cnf_aboutus-aproposdenous_fcen-eng.php

Health Canada. (2007c). Food and nutrition, what is a food guide serving? Retrieved Sep 15th, 2015, from: http://www.hc-sc.gc.ca/fn-an/food-guide-aliment/basics-base/serving-portion-eng.php

Institute of Medicine. (2001). *Dietary reference intakes for vitamin a, vitamin k, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc : A report of the panel on micronutrients*. Washington, D.C.: National Academies Press.

Institute of Medicine. (2005). *Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids*. Washington, D.C: National Academies Press.

Isanaka, S., Mora-Plazas, M., Lopez-Arana, S., Baylin, A., & Villamor, E. (2007). Food insecurity is highly prevalent and predicts underweight but not overweight in adults and school children from Bogotá, Colombia. *J Nutr, 137*(12), 2747-2755.

Johnson-Spear, M. A., & Yip, R. (1994). Hemoglobin difference between black and white women with comparable iron status: Justification for race-specific anemia criteria. *Am J Clin Nutr, 60*(1), 117-121.

Jyoti, D. F., Frongillo, E. A., & Jones, S. J. (2005). Food insecurity affects school children's academic performance, weight gain, and social skills. *J Nutr, 135*(12), 2831-2839.

Kendall, A., Olson, C. M., & Frongillo, E. A. (1996). Relationship of hunger and food insecurity to food availability and consumption. *J Am Diet Assoc, 96*(10), 1019-1024; quiz 1025-1016.

Kirkpatrick, S. I., Dodd, K. W., Parsons, R., Ng, C., Garriguet, D., & Tarasuk, V. (2015). Household food insecurity is a stronger marker of adequacy of nutrient intakes among Canadian compared to American youth and adults. *J Nutr, 145*(7).

Kirkpatrick, S. I., & Tarasuk, V. (2008). Food insecurity is associated with nutrient inadequacies among Canadian adults and adolescents. *J Nutr, 138*(3), 9.

Mark, S., Lambert, M., O'Loughlin, J., & Gray-Donald, K. (2012). Household income, food insecurity and nutrition in Canadian youth. *Can J Public Health, 103*(2), 94-99.

Matheson, D. M., Varady, J., Varady, A., & Killen, J. D. (2002). Household food security and nutritional status of Hispanic children in the fifth grade. *Am J Clin Nutr, 76*(1), 210-217.

Nord, M. (2014). *Introduction to item response theory applied to food security measurement: basic concepts, parameters and statistic.* Rome. Retrieved Oct 13th, 2015, from: http://www.fao.org/3/a-i3946e.pdf

Nord, M., & Hopwood, H. (2008). *A comparison of household food security in Canada and the United States.* Retrieved Oct 15th, 2015, from: http://www.ers.usda.gov/media/191355/err67.pdf

PAHO. (1997). *Health conditions in the Caribbean.*Washington, D.C. Retrieved Oct 15th, 2015, from: http://apps.who.int/bookorders/anglais/detart1.jsp?codlan=1&codcol=61&codcch=561

Phillip, L. E., & Francis-Granderson, I. (2014). *Improving the nutrition and health of CARICOM populations:final technical report (March 2011 - August 2014)*. Retrieved Oct 15th, 2015, from: https://idl-bnc.idrc.ca/dspace/handle/10625/53596

Popkin, B., Adair, L., & Ng, S. (2012). Global nutriiton transition and the pandemic of obesity in developing countries. *Nutr Rev, 70*(1), 3-21.

Schwiebbe, L., van Rest, J., Verhagen, E., Visser, R. W., Holthe, J. K., & Hirasing, R. A. (2011). Childhood obesity in the Caribbean. *West Indian Med J, 60*(4), 442-445.

Skalicky, A., Meyers, A. F., Adams, W. G., Yang, Z., Cook, J. T., & Frank, D. A. (2006). Child food insecurity and iron deficiency anemia in low-income infants and toddlers in the United States. *Matern Child Health J, 10*(2), 177-185.

UNICEF. (2013a). Colombia, statistics, nutrition. Retrieved Nov 3rd, 2015, from: http://www.unicef.org/infobycountry/colombia_statistics.html

UNICEF. (2013b). Pakistan, statistics, nutrition. Retrieved Nov 3rd, 2015, from: http://www.unicef.org/infobycountry/pakistan_pakistan_statistics.html

UNICEF. (2013c). Tanzania, United Republic of, statistics, nutrition. Retrieved Nov 3rd, 2015, from: http://www.unicef.org/infobycountry/tanzania_statistics.html

USDA. (2012). U.S. household food security survey module: three-stage design, with screeners, Economic Research Service. Retrieved Oct 15th, 2014, from:

http://www.ers.usda.gov/datafiles/Food_Security_in_the_United_States/Food_Security_Survey_Modules/hh2012.pdf

WHO. (2013). BMI-for-age (5-19 years). Retrieved May 20th, 2015, from: http://www.who.int/growthref/who2007_bmi_for_age/en/

WHO. (2015). BMI classification. Retrieved May 10th, 2016, from: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html

WHO, & CDC. (2008). Worldwide prevelence of anaemia 1993-2005: WHO global database on anaemia. Retrieved Sep 13th, 2015, from: http://apps.who.int/iris/bitstream/10665/43894/1/9789241596657_eng.pdf

WHO, & FAO. (2002). *Diet, nutrition and the prevention of chronic diseases, report of a joint WHO/FAO expert consultation*. Geneva. Retrieved Oct 15th, 2015, from: ftp://ftp.fao.org/docrep/fao/005/ac911e/ac911e00.pdf

Xuereb, G., Johnson, P., Morris, A., Bocage, C., Trotter, P., & Henry, F. (2001). Obesity in Caribbean children: its magnitude and current control efforts. *34*(3), 6.

Zephirin, & Manuelita, P. (1990). *Manual of Nutrition and Dietetic Practice for the Caribbean*: CFNI, PAHO, WHO.

Table 1. Demographic characteristics by food security status in children and their caregivers (n=390)

	Food Secure (n=228)	**Food Insecure (n=162)**	***p***
Child			
Age, y [a]	9.2 ± 0.97	9.3 ± 0.99	0.210
Girls [b]	49.8	47.5	0.662
Caregiver			
Age, y [a] *	36.1 ± 9.06	34.0 ± 8.32	0.036
BMI kg/m^2 [a]	40.4 ± 8.85	39.9 ± 9.50	0.628
Overweight/Obese [b]	97.7	96.1	0.422
Female [b]	93.5	94.7	0.662
Unmarried female [b] *	57.9	71.2	0.023
Household size [a]	4.9 ± 1.74	5.3 ± 1.77	0.067
Education, less than secondary [b]	40.0	51.0	0.095

[a] mean ± SD
[b] %
* Indicate significance at the 0.05 level

Table 2. Food and nutrient intake by household food security status among children (n=390)

	Food Secure (n=228)	**Food Insecure (n=162)**	***p***
Staples, portions	5.0 ± 2.8	4.77 ± 3.24	0.224
Ground provisions, portions	0.36 ± 0.95	0.35 ± 0.64	0.220
Meat, portions	1.7 ± 1.4	1.4 ± 1.2	0.127
Legumes and nuts, portions	0.22 ± 0.50	0.24 ± 0.48	0.200
Milk, portions	0.66 ± 1.08	0.54 ± 0.76	0.606
Fruits, portions	1.0 ± 1.5	1.1 ± 1.6	0.972
Vegetables, portions	0.56 ± 0.86	0.53 ± 0.89	0.790
Energy, kcal	1728 ± 620	1635 ± 634	0.105
Carbohydrate, g	248 ± 99.0	243 ± 100	0.704
Protein, g *	59.6 ± 31.5	50.9 ± 24.4	0.003
Fat, g	56.5 ± 30.3	52.5 ± 28.6	0.170
Fiber, g	11.0 ± 6.79	11.3 ± 6.2	0.554
Calcium, mg	535 ± 384	491 ± 294	0.296
Iron, mg	12.2 ± 8.9	11.3 ± 8.4	0.076
Potassium, mg	1540 ± 762	1447 ± 661	0.225
Vitamin A, µg	627 ± 864	552 ± 841	0.190
Vitamin C, mg	175 ± 149	186 ± 185	0.358
Zinc, mg *	7.3 ± 5.0	6.2 ± 3.5	0.004
Total sugar, g	104 ± 56.8	103 ± 55.0	0.794

Values in cells are means ± SD
* Indicate significance at the 0.005 level
Note: Foods were grouped based on the Six Caribbean Food Groups; “milk products” group was a subcategory from “food from animals”, and “ground provisions” group was a subcategory from “staples”
Serving sizes were calculated based on Canada's Food Guide

Table 3. Children's weight status by household food security status (n=390)

	Food Secure (n=228)	Food Insecure (n=162)	*p*
Height-for-age z-score *	0.46 ± 1.0	0.38 ±1.2	0.511
Stunting	0.44	2.5	0.079
BMI z-score *	0.44 ± 1.5	0.30 ± 1.5	0.399
Wasting	4.4	7.6	0.194
Healthy weight	62.4	63.5	0. 496
Overweight	13.7	13.8	
Obese	19.5	15.1	
Overweight/obese	33.2	28.9	0.375

Note: Values in cells are percentages unless otherwise specified
* Mean ± SD

Table 4. Children's anemia status using race-specific cut-offs for Afro-Caribbean children by household food security status (n=331)

	Food Secure (n=209)	Food Insecure (n=156)	*p*
Anemic	23.2	39.0	0.002
Hemoglobin, mean ± SD	11.9 ± 1.4	11.5 ± 1.4	0.004

Supplementary Table 1: Item calibrations and item-fit statistics of items in the 18-item U.S. Household Food Security Survey Module of the USDA

Item	Item calibration*	Item infit	Item outfit
In the last 12 months, did (your child/any of the children) ever not eat for a whole day because there wasn't enough money for food?	5.93	1.20	1.70
In the last 12 months, did (you/ you or other adults in your household) ever not eat for a whole day because there wasn't enough money for food?	3.39	0.86	1.09
In the last 12 months, did you lose weight because there wasn't enough money for food?	3.11	0.89	0.28
In the last 12 months, did (child's name/any of the children) ever skip meals because there wasn't enough money for food?	2.60	0.77	0.29
In the last 12 months, (was your child/were the children) ever hungry but you just couldn't afford more food?	2.28	1.03	1.57
In the last 12 months, since (current month) of last year, did you ever cut the size of (your child/any of the children's) meals because there wasn't enough money for food?	0.84	0.77	0.42
In the last month, were you ever hungry but didn't eat because there wasn't enough money for food?	0.74	0.98	0.54
"(My/our child was/the children were) not eating enough because (I/we) just couldn't afford enough food." Was that often, sometimes, or never true for (you/your household) in the last 12 months?	0.19	0.84	0.40
In the last 12 months, since last (name of current month), did (you/you or other adults in your household) ever cut the size of your meals or skip meals because there wasn't enough money for food?	− 0.07	1.00	0.75
In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food?	− 0.70	0.79	0.61
"(I/we) couldn't feed (my/our) child/the children) a balanced meal, because (I/we) couldn't afford that." Was that often, sometimes, or never true for (you/your household) in the last 12 months?	− 2.14	0.91	0.72
"(I/We) relied on only a few kinds of low-cost food to feed (my/our) child/the children) because (I was/we were) running out of money to buy food." Was that often,	− 2.78	1.09	1.15

sometimes, or never true for (you/your household) in the last 12 months?			
"The food that (I/we) bought just didn't last and (I/we) didn't have money to get more." Was that often, sometimes, or never true for (you/your household) in the last 12 months?	− 3.77	0.85	1.31
"(I/we) couldn't afford to eat balanced meals." Was that often, sometimes, or never true for (you/your household) in the last 12 months?	− 3.78	1.19	9.90
"(I/We) worried whether (my/our) food would run out before (I/we) got money to buy more." Was that often, sometimes, or never true for (you/your household) in the last 12 months?	− 5.83	1.15	2.07

*Item calibration indicates the severity of the item
Note: validation of items was done using WINSTEP software

BRIDGING STATEMENT

Chapter 3 established that food insecurity is highly prevalent in the Caribbean, but dietary intake, with the exception of protein and zinc, was not associated with food insecurity. Stunting and underweight were not evident in the population sampled but anemia was more prevalent among children from food insecure households. What is very evident is that caregivers are overweight and obese and approximately 30% of children measured were overweight or obese. There is a shift from under-nutrition to over-nutrition among children in these countries, which is relatively new and not widely studied. Unfortunately there is little known about the determinants of overweight in children, making it difficult to target this public health problem with appropriate interventions. Very few studies examine the predictors of change in adiposity over time, as most are simply cross-sectional and do not address important changes in adiposity as children get older. In the second study (chapter 4), increased adiposity and its determinants among children were more closely examined. Weight change over an 18 months period was examined using change in BMI. Dietary and anthropometric nutritional measures as well as family variables including household food security, education and caregiver weight were explored as predictors of change in adiposity.

CHAPTER IV. PREDICTORS OF INCREASED ADIPOSITY IN CARIBBEAN SCHOOL-AGED CHILDREN

Authors

1. Walaa A. Mumena, Ph.D. Candidate, School of Dietetics and Human Nutrition, McGill University, Sainte-Anne-de-Bellevue, Québec, Canada
2. Isabella Francis-Granderson, Principle Investigator of the CARICOM food security project, Faculty of Food and Agriculture, University of the West Indies, St. Augustine Campus, Trinidad and Tobago
3. Leroy E. Phillip, Principle Investigator of the CARICOM food security project, Department of Animal Science, McGill University, Sainte-Anne-de-Bellevue, Québec, Canada
4. Katherine Gray-Donald, School of Dietetics and Human Nutrition, McGill University, Sainte-Anne-de-Bellevue, Québec, Canada

4.1. Abstract

Background: Obesity is rapidly increasing among children in developing countries. There is a dearth of longitudinal studies examining nutritional predictors of increasing weight over time among children in these settings.

Objective: This longitudinal study aims to examine the predictors of increasing overweight over time among children in two developing countries which are classified as upper-income.

Methods: Children (6-10 y at baseline) from Trinidad and Tobago, and St. Kitts and Nevis and their caregivers (n=336 dyads) were followed for 18 months to examine predictors of increasing body mass index (BMI) adjusted for age and sex. The children were recruited from eight schools in Trinidad and seven schools in St. Kitts. Children's measured height and weight, dietary intake and caregiver demographic information and anthropometry were collected at baseline in 2012, with follow-up 18 months later. Misreporting of energy intake was assessed using Goldberg cut-offs.

Results: At baseline, children's age and sex and caregivers' BMI, age, sex and marital status were similar across all weight status groups. The incidence of children becoming overweight was 8.8% and 8.1% became obese. Dietary intakes were similar among children across all weight categories at baseline, as well as among children who become overweight or obese compared to children who did not, only the latter group were found to have higher intake of fruit. Misreporting of energy intake was evident among overweight and obese children as compared to children who were within the healthy weight range at baseline (27% vs. 17%, p=0.047). Predictors of increasing BMI adjusted for age and sex were older age, higher BMI z-score and height-for-age (HFA) z-score of the children at baseline, while caregiver BMI, household food

insecurity, sex and energy intake (with adjustment of misreporting of energy intake) did not predict change in children's BMI.

Conclusion: Increasing overweight and obesity in the Caribbean is a serious problem among school-aged children. Heavier children are at elevated risk of continued rapid increase in their weight for height, pointing to the need for early intervention and support.

4.2. Introduction

Obesity has increased over the last few decades to become a worldwide public health problem (Nguyen & El-Serag, 2010), it is becoming more prevalent among all age groups including children in developing countries (Ng et al., 2013). Childhood obesity is a matter of concern, as these children are at higher risk of becoming obese adults (Freedman, Khan, Dietz, Srinivasan, & Berenson, 2001; Guo & Chumlea, 1999; Serdula et al., 1993) and are at increased risk of non-communicable chronic diseases, such as diabetes and coronary heart disease, later in life (Lambert et al., 2008). Moreover, obese children already have a higher prevalence of insulin resistance (Romualdo, Nóbrega, & Escrivão, 2014; Shalitin, Abrahami, Lilos, & Phillip, 2005) and elevated blood pressure (Sorof & Daniels, 2002). Predictors of overweight and obesity among children in the developed world are well investigated, but this is not the case in upper-income developing countries despite important increases in weight-for-height. Low physical activity (Hill, Wyatt, & Peters, 2012; O'Loughlin, Gray-Donald, Paradis, & Meshefedjian, 2000), high baseline BMI (O'Loughlin, Gray-Donald, Paradis, & Meshefedjian, 2000) and parental BMI (O'Loughlin, Gray-Donald, Paradis, & Meshefedjian, 2000; Parikka et al., 2015; Wrotniak, Epstein, Paluch, & Roemmich, 2004) are the most common predictors of weight gain reported in developed countries. Also, energy intake has been reported to be an important predictor of weight status of children and adolescents (Hebestreit et al., 2014; Stice & Durant, 2014) as well as certain dietary patterns (Receveur, Morou, Gray-Donald, & Macaulay, 2008; Shang, O'Loughlin, Tremblay, & Gray-Donald, 2014).

It has been suggested that the “nutrition transition”, the shift to more “Westernized” dietary practices and increasingly sedentary lifestyles, is linked to the increased prevalence of childhood overweight and obesity in developing countries (Amuna & Zotor, 2008; Popkin, Adair, & Ng, 2012). Prevalence of overweight and obesity among Caribbean children is increasing systematically; obesity among children in Dominica has increased from 6.0% to 9.7% between 1990 and 1999, while in St. Kitts the prevalence has increased from 7.1% to 10.6% during the same period (Xuereb et al., 2001). More recent data from Barbados show a rapid increase in the prevalence of overweight and obesity among grade three students (n=580) from 8.5% to 32.5% between 1981 and 2010 using identical reference standards (Fernandez, Kubow, Gray-Donald, Knight, & Gaskin, 2015).

The purpose of this study was to determine the incidence of becoming overweight or obese over a relatively short period of time and examine dietary and other predictors of increasing adiposity for children aged 6 to 10 years living in Trinidad and Tobago and St. Kitts and Nevis.

4.3. Methods

This study was part of a broader multidisciplinary project dealing with food and nutrition security, with a focus on improving nutritional outcomes of children in the Caribbean region reported elsewhere (Phillip & Francis-Granderson, 2014). Ethical approvals were obtained from the McGill Ethics Review Board and Ministries of Education and the Ministries of Health in Trinidad and Tobago and St. Kitts and Nevis.

Data for this study were collected between January and July 2012 in a first phase and follow-up data were collected between September 2013 and April 2014. Children aged 6-10 years and their caregivers were recruited from eight schools in Trinidad and Tobago and seven schools in St. Kitts and Nevis. In Trinidad, schools were selected from those with a high proportion of children who consumed the government supplied school lunch, which is offered to families in need. Schools in St. Kitts, where all children are offered a free lunch, were selected from rural areas near the capital. A letter requesting caregiver and child participation was sent home. Children with signed parental consent were enrolled. For families with more than one child in the age range, one child was randomly chosen. Trained interviewers collected a single 24-hour dietary recall for each child done at home with the child and caregiver together as recommended (Eck, Klesges, & Hanson, 1989). Demographic variables including caregiver's age, sex, marital status, education and household size were collected along with measured height and weight of the caregiver during a home interview. Children's height and weight were measured at school.

Height was measured as standing height using a stadiometer, and body weight was measured using a digital floor scale. Caregiver body mass index (BMI) was calculated as kilograms per height squared in meters (kg/m^2) to classify caregiver weight status. Body mass index (z-score) BMI z- score was used to classify children's weight status. Children's change in BMI was calculated as suggested by Cole et al. (Cole, Faith, Pietrobelli, & Heo, 2005) to avoid the ceiling effect of high percentiles and modeled z-scores. Change in children's adiposity was calculated by subtracting the sex–age-specific median BMI using the WHO reference from the measured BMI from baseline and follow-up measures. The height-for-age z-score (HFA z-score) was calculated using the WHO reference at each time point (WHO, 2015b). The WHO cut-offs for children aged 5-19 years were used, as recommended for international comparison (de Onis et al., 2007). As an additional outcome measure to the adjusted change in BMI, a child was considered an incident case of overweight or obesity when a healthy weight child became overweight or obese and when an overweight child became obese.

One 24-hour dietary recall was conducted at baseline by trained local interviewers. Caregivers and their children were asked to provide details on the types and amounts of foods that were consumed by the child on the previous day (including vitamin and mineral supplements). Portion models (Santé Quebec, Montreal, Canada) were used to help estimate amounts consumed in milliliters which were converted to grams for data entry for each food item. CANDAT Nutrient Analysis Software (Godin London Incorporated, London, ON), was used for the nutrient analysis based on the Canadian Nutrition Files (CNF) released in 2010 (Health Canada, 2007a). Where processed foods were locally produced, food labels or local recipes were added to the database. Foods groups were formed based on the Six Caribbean Food Groups (staples, legumes and nuts, foods from animals, fruits, vegetables, fats and oils) (Zephirin & Manuelita, 1990). Green banana, plantain, breadfruit, corn, sweet potato and cassava are staples based on the Caribbean Food Groups, and serving sizes for these foods were calculated based on average carbohydrate content in one serving of grain. Portions of all other foods followed Canada's Food Guide (CFG) portion sizes (Health Canada, 2007b). As the mean intake of a single day is a reliable measure of the intake of groups (Beaton et al., 1979), this was used to compare the dietary intake of children who became overweight or obese versus children who remain at the same weight category. Food groupings were not used in regression models as the foods eaten each child on one day is not representative of usual intake of that food group.

Household food security status was assessed using an adapted version of the United States Department of Agriculture (USDA) Household Food Security Scale, which was validated previously in a Caribbean setting (Gulliford, Mahabir, & Rocke, 2004). The responses to this six-item short form of the Food Security Survey Module were used to classify household food security status at baseline. Household food security status was categorized as food secure or food insecure household based on standard procedure (USDA, 2012).

To examine the extent of misreporting of energy intake and to adjust for it in the analysis, the ratio of reported energy intake (EI) over total energy expenditure (TEE) was used to classify children to the appropriate misclassification group based on Goldberg cut-offs. Total energy expenditure was determined for each child using Torun equations (Torun, 2005). A detailed explanation of this method is available elsewhere (Black, 2000).

4.4. Statistical analysis

Descriptive data for characteristics of children and their caregivers were presented as means ± SDs, and categorical variables were presented as percentages. WHO cut-off points were used to define caregivers weight status which are: thinness <18.5 kg/m^2, healthy weight 18.5-24.9 kg/m^2, overweight 25-29.9 kg/m^2, obesity ≥30 kg/m^2 (WHO, 2015a). The WHO cut-off points for BMI z-score to define children's weight status are (severe thinness, < −3 SD; thinness, < −2 SD; overweight, >1 SD; and obesity, >2 SD) (WHO, 2013). Children were classified as either under-reporters, defined as having a ratios of EI:TEE <0.76 for both boys and girls, plausible-reporters having ratios of EI:TEE between 0.76 and 1.24 and over-reporters having ratios of > 1.24 (Black, 2000).

Multiple regression analysis was performed to test for association between baseline BMI z-score, baseline HFA z-score, age, sex (boy= 1, girl= 2), energy intake, misreporting of energy intake (under-reporters= −1, plausible-reporters= 0, over-reporters= 1), food insecurity (food secure= 0, food insecure= 1) and caregiver BMI in relation to the change of children's BMI. All statistical tests were 2-tailed, and a significance level of $p < 0.05$ was used. Correcting for multiple comparisons (dietary intake and weight category) was done using the Bonferroni method ($p < 0.004$). Statistical analyses were performed using SAS® software version 9.4 (2013, SAS Institute Inc., Cary, NC, USA).

4.5. Results

A total of 336 children and their caregivers were included in this study. We excluded 77 children (15.6%) for missing dietary data and 78 children (15.7%) were excluded due to missing anthropometric data. Also, we excluded 3 children (0.60%) for very low < 700 kcal or high > 3800 kcal reported energy intake. Demographic variables at baseline by children's weight category (thinness, healthy weight, overweight, obese) are shown in **Table 1**. Caregivers were mostly female (94%) and overweight or obese (mean BMI 40.1 ± 9.08 kg/m^2). There were no differences in children's age or sex among the different weight categories. Only children's HFA z-scores at baseline were significantly different across the different weight groups, with taller children being in the heavier BMI categories. Caregivers were similar in age, sex, marital status, food insecurity and BMI across all children's weight categories at baseline.

Children's weight status at baseline and follow-up is shown in **Table 2**. At baseline 22.0% of children were overweight or obese, while at follow-up 28.6% were overweight or obese. At follow-up, the percentage of healthy weight range children decreased by 6.8%, while the percentage of overweight children remained the same and the percentage of obese children increased by 6.9%. The incidences of becoming overweight or obese was calculated for each outcome. The numerator was defined as children who become overweight or obese during 18 months period. The populations in the denominators were defined as those who were at risk of becoming overweight (BMI z-score ≤ 1 SD) or obese (BMI z-score ≤ 2 SD) over an 18 months period. Among those included in the final sample, 262 children were at risk of becoming overweight and 307 children were at risk of becoming obese. The incidence of becoming overweight was 8.8% and that of becoming obese was 8.1%. A total of 15.1% (n=48) of children moved up to a higher weight category to become either overweight or obese, while only 1.58%

(n=5) children moved down a weight category (overweight to healthy weight). The number of thin children (BMI z-scoe < −2 SD) remained constant.

Baseline dietary intakes of children were similar across the different baseline weight categories (thinness, healthy weight, overweight, obese). The dietary intake of children who become overweight or obese was generally similar to the intake of children who did not become overweight or obese (those who moved up a weight category to become overweight or obese or not, excluding thin children). The one exception was that children who did moved up a weight category on average consumed less servings of fruit **Table 3**.

Using multiple regression analysis we found that higher baseline BMI z-score, higher baseline HFA z-score and older age of children predicted increased adiposity between the two measurements. For each additional unit of baseline BMI z-score, the BMI increased by 0.47 BMI units adjusted for age and sex indicating that the heaviest children gained the most. Child's sex, energy intake, and the misreporting of energy intake as well as family factors including household food security, caregiver education and BMI were examined but none were associated with increasing BMI adjusted for age and sex. Misreporting of energy intake was examined to verify the validity of the dietary data. Higher under-reporting was found among overweight and obese children as compared to children who were not overweight or obese (27% vs. 17%, p=0.047). Thus, misreporting was adjusted for in our regression model to minimize under-reporting's potential effect on measuring the contribution of energy intake to a change in adiposity that might be caused by under-reporting. The final model presents only those variables that had a significant impact on the change in BMI, see **Table 4**.

As it is important to measure the magnitude of gain in relation to baseline weight, we examined the change in BMI for each quartile of baseline BMI z-score. The average BMI change in the thinnest quartile was positive at 0.68 of a BMI unit adjusted for age and sex. The gain in the children in the highest quartile was considerably higher at 2.5 BMI units (p<0.001), see **Table 5**. This increase in BMI units translates to an average weight gain of 12 kg (mean weight 32 kg at baseline and 44 kg at follow-up) for a child in the heaviest quartile which can be compared to an average weight gain of 5 kg (25 to 30 kg) if the child gained weight following changes expected at the median.

4.6. Discussion

In the present study we investigated the development of overweight and obesity among school-aged children in the Caribbean over 18 months and predictors of increasing BMI over time. There were important increases in overweight and obesity over the study period with 15% becoming overweight or obese vs. <2% of overweight/obese children getting into a healthier weight category. There were no differences in dietary intake among children in different weight categories at baseline, but a lower consumption of fruit was evident in those who increased a weight category. The major predictor of gains in BMI was the baseline BMI z-score, indicating that heavier children are those most likely to become even heavier. Taller children for their age at baseline become heavier for their height more rapidly as well. Household food security, caregiver BMI, children's sex and energy intake (with adjustment of misreporting of energy intake) were not related to the change in children's BMI.

The rapid increase in the prevalence of overweight and obesity among our sample of children was reflected by the mean change in BMI (adjusted for age and sex), which was 1.3 kg/m^2. This increase above the WHO standard for growth at this age was less than observed in children aged 8-10 years in Québec (1.7 kg/m^2). Both studies investigated changes in adiposity among children whose parents were overweight or obese (Kakinami, Henderson, Chiolero, Cole,

& Paradis, 2014). Lower mean weight gains among our sample could be due to including younger children in the study (aged 6-10 years vs. 8-10 years in the Québec study) and the Quebec study had a higher baseline level of overweight. In the Caribbean children, 9% of children increased their weight categories to become overweight and 8.1% became obese over the study period. These finding are high when compared to findings from an Australian cohort study among children aged 5-10 years at baseline (n=1,438) where the incidence of overweight was similar but that for obesity was much lower over a longer study period of 3 years (1997-2000), the values were 9.7% and 1.7% respectively (Hesketh, Wake, Waters, Carlin, & Crawford, 2004).

Increased prevalence of overweight and obesity indicate an imbalance of energy intake and physical activity at the population level (Hill, Wyatt, & Peters, 2012). It is challenging for children to balance their energy intake when their level of physical activity decreases. Misreporting of dietary intake data is a major challenge in gaining a better understanding of the foods actually consumed. Adjusting for the misreporting of energy intake when analyzing the data in order to establish more accurate epidemiological relationships is suggested (Subar et al., 2015), but the problem of knowing which foods are misreported remains a challenge and may lead to failing to pick up some types of foods that increase the risk of excessive weight gain.

Dietary intakes were similar among children from all weight categories and children who become overweight or obese versus children who did not, only fruit intake was lower among children who moved up weight category compared to children who did not move up weight category. The relationship between fruit and/or vegetable intake and weight gain is evident among adults but among children findings have been inconsistent, with some but not all showing a protective effect of fruits and vegetables (Ledoux, Hingle, & Baranowski, 2011).

In this study, children with higher weight at baseline gained the most weight after 18 months and this is in line with findings of other studies. It has been reported in North America that heavier children are gaining weight more quickly than healthy weight children (Butte et al., 2007; O'Loughlin, Gray-Donald, Paradis, & Meshefedjian, 2000) and reports indicate that approximately 50% of obese school-aged children will become obese adults (Serdula et al., 1993). Height and age were also strong predictors for increased adiposity and that is in line with previous findings (Freedman et al., 2002; Frye & Heinrich, 2003).

Also, previous studies have identified a positive association between parental BMI and children's weight status (Maffeis, Talamini, & Tato, 1998; Parikka et al., 2015; Wrotniak, Epstein, Paluch, & Roemmich, 2004). In this study, however, 97% of the caregivers were identified as overweight or obese, making it very difficult to study. In addition, sex was not associated with a change in adiposity, even though girls tend to have a higher prevalence of obesity later in life (CFNI & PAHO, 2010). This could be due to the fact that weight gain peaks for both girls and boys after the age of 12 years (for girls 12.5 years and for boys 14 years) (Barnes, 1975; Tanner, 1965), and no sex difference is evident before this age. Thus, an association between sex and weight gain may not be evident before this age. The lack of association between household food insecurity and increase in adiposity is also in line with previous studies where no association of food insecurity and obesity among children in both developing and developed countries has been reported (Matheson, Varady, Varady, & Killen, 2002; Metallinos-Katsaras, Must, & Gorman, 2012; Schlüssel, Silva, Pérez-Escamilla, & Kac, 2013).

The major strengths of this study is the longitudinal study design, which allows us to measure adiposity change in individuals and not just secular changes over time. In addition, misreporting of energy intake was assessed among our sample and controlled for in the regression analysis. Energy intake alone should not be used to measure energy balance unless misreporting is accounted for. Several limitations of this study should also be considered. Our sample is not representative of the general population in the Caribbean, as schools in Trinidad were chosen based on their having a high proportion of children receiving the free school lunch offered to families in need. In this study, physical activity was measured by questionnaire only, and spontaneous play and movement were not captured, making this data unreliable (Welk, Corbin, & Dale, 2000).

In conclusion, overweight and obesity is known to be a rapidly growing problem among Caribbean children when examined in relation to children of the same age at different points in time. Predictors of excessive weight gain in individual children clearly show that the heaviest children gain the most rapidly. Interventions early in life are particularly important to maintain healthy weights into adulthood and there is a need to recognize that the heavier children are at highest risk.

4.7. References

Amuna, P., & Zotor, F. B. (2008). Epidemiological and nutrition transition in developing countries: impact on human health and development. *Proc Nutr Soc, 67*(1), 82-90.

Barnes, H. V. (1975). Physical growth and development during puberty. *Med Clin North Am, 59*(6), 1305-1317.

Beaton, G. H., Milner, J., Corey, P., McGuire, V., Cousins, M., Stewart, E., . . . Little, J. A. (1979). Sources of variance in 24-hour dietary recall data: implications for nutrition study design and interpretation. *Am J Clin Nutr, 32*(12), 2546-2559.

Black, A. E. (2000). The sensitivity and specificity of the Goldberg cut-off for EI:BMR for identifying diet reports of poor validity. *Eur J Clin Nutr, 54*(5), 395-404.

Butte, N. F., Cai, G., Cole, S. A., Wilson, T. A., Fisher, J. O., Zakeri, I. F., . . . Comuzzie, A. G. (2007). Metabolic and behavioral predictors of weight gain in Hispanic children: the Viva la Familia Study. *Am J Clin Nutr, 85*(6), 1478-1485.

CFNI, & PAHO. (2010). *The contribution of CFNI to Caribbean development 2001-2010*. Kingston. Retrieved April 21st, 2016, from: http://iris.paho.org/xmlui/bitstream/handle/123456789/9991/CFNIREPORT_2011.pdf?sequence=1&isAllowed=y

Cole, T. J., Faith, M. S., Pietrobelli, A., & Heo, M. (2005). What is the best measure of adiposity change in growing children: BMI, BMI %, BMI z-score or BMI centile. *Eur J Clin Nutr, 59*(3), 419-425.

de Onis, M., Onyango, A. W., Borghi, E., Siyam, A., Nishida, C., & Siekmann, J. (2007). Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ, 85*(9), 660-667.

Eck, L. H., Klesges, R. C., & Hanson, C. L. (1989). Recall of a child's intake from one meal: are parents accurate? *J Am Diet Assoc, 89*, 784-787.

Fernandez, M. A., Kubow, S., Gray-Donald, K., Knight, J., & Gaskin, P. S. (2015). Drastic increases in overweight and obesity from 1981 to 2010 and related risk factors: results from the Barbados children's health and nutrition study. *Public Health Nutr*, 1-8.

Freedman, D. S., Khan, L. K., Dietz, W. H., Srinivasan, S. A., & Berenson, G. S. (2001). Relationship of childhood obesity to coronary heart disease risk factors in adulthood: the Bogalusa heart study. *Pediatrics, 108*(3), 712–718.

Freedman, D. S., Khan, L. K., Mei, Z., Dietz, W. H., Srinivasan, S. R., & Berenson, G. S. (2002). Relation of childhood height to obesity among adults: The Bogalusa Heart Study. *Pediatrics, 109*(2), E23.

Frye, C., & Heinrich, J. (2003). Trends and predictors of overweight and obesity in East German children. *Int J Obes Relat Metab Disord, 27*(8), 963-969.

Gulliford, M. C., Mahabir, D., & Rocke, B. (2004). Reliability and validity of a short form household food security scale in a Caribbean community. *BMC Public Health, 4*(22).

Guo, S. S., & Chumlea, W. C. (1999). Tracking of body mass index in children in relation to overweight in adulthood. *Am J Clin Nutr, 70*(1), 145s–148s.

Health Canada. (2007a). Food and nutrition, the Canadian nutrient file. Retrieved Oct 6th, 2015, from: http://www.hc-sc.gc.ca/fn-an/nutrition/fiche-nutri-data/cnf_aboutus-aproposdenous_fcen-eng.php

Health Canada. (2007b). Food and nutrition, what is a food guide serving? Retrieved Sep 15th, 2015, from: http://www.hc-sc.gc.ca/fn-an/food-guide-aliment/basics-base/serving-portion-eng.php

Hebestreit, A., Börnhorst, C., Barba, G., Siani, A., Huybrechts, I., Tognon, G., . . . Krogh, V. (2014). Associations between energy intake, daily food intake and energy density of foods and BMI z-score in 2-9-year-old European children. *Eur J Nutr, 53*(2), 673-681.

Hesketh, K., Wake, M., Waters, E., Carlin, J., & Crawford, D. (2004). Stability of body mass index in Australian children: a prospective cohort study across the middle childhood years. *Public Health Nutr, 7*(2), 303-309.

Hill, J. O., Wyatt, H. R., & Peters, J. C. (2012). Energy balance and obesity. *Circulation, 126*(1), 126-132.

Kakinami, L., Henderson, M., Chiolero, A., Cole, T. J., & Paradis, G. (2014). Identifying the best body mass index metric to assess adiposity change in children. *Arch Dis Child, 99*(11), 1020-1024.

Lambert, M., Delvin, E. E., Levy, E., O'Loughlin, J., Paradis, G., Barnett, T., & McGrath, J. J. (2008). Prevalence of cardiometabolic risk factors by weight status in a population-based sample of Quebec children and adolescents. *Can J Cardiol, 24*(7), 575-583.

Ledoux, T. A., Hingle, M. D., & Baranowski, T. (2011). Relationship of fruit and vegetable intake with adiposity: a systematic review. *Obes Rev, 12*(5), e143-150.

Maffeis, C., Talamini, G., & Tato, L. (1998). Influence of diet, physical activity and parents' obesity on children's adiposity: a four-year longitudinal study. *Int J Obes, 22*(8), 758-764.

Matheson, D. M., Varady, J., Varady, A., & Killen, J. D. (2002). Household food security and nutritional status of Hispanic children in the fifth grade. *Am J Clin Nutr, 76*(1), 210-217.

Metallinos-Katsaras, E., Must, A., & Gorman, K. (2012). A longitudinal study of food insecurity on obesity in preschool children. *J Acad Nutr Diet, 112*(12), 1949-1958.

Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., & Margono, C. (2013). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the global burden of disease study 2013. *The Lancet, 384*(9945), 766-781.

Nguyen, D. M., & El-Serag, H. B. (2010). The Epidemiology of Obesity *Gastroenterology Clinics of North America, 39*(1), 1-7.

O'Loughlin, J., Gray-Donald, K., Paradis, G., & Meshefedjian, G. (2000). One- and two-year predictors of excess weight gain among elementary schoolchildren in multiethnic, low-income, inner-city neighborhoods. *Am J Epidemiol, 152*(8), 739-746.

Parikka, S., Mäki, P., Levälahti, E., Lehtinen-Jacks, S., Martelin, T., & Laatikainen, T. (2015). Associations between parental BMI, socioeconomic factors, family structure and overweight in Finnish children: a path model approach. *BMC Public Health, 15*(1), 271.

Phillip, L. E., & Francis-Granderson, I. (2014). *Improving the nutrition and health of CARICOM populations:final technical report (March 2011 - August 2014)*. Retrieved April 20th, 2016, from: https://idl-bnc.idrc.ca/dspace/handle/10625/53596

Popkin, B. M., Adair, L. S., & Ng, S. W. (2012). Global nutrition transition and the pandemic of obesity in developing countries. *Nutr Rev, 70*(1), 3-21.

Receveur, O., Morou, K., Gray-Donald, K., & Macaulay, A. C. (2008). Consumption of key food items is associated with excess weight among elementary-school-aged children in a Canadian first nations community. *J Am Diet Assoc, 108*(2), 362-366.

Romualdo, M. C., Nóbrega, F. J., & Escrivão, M. A. (2014). Insulin resistance in obese children and adolescents. *Jornal de pediatria, 90*(6), 600-607.

Schlüssel, M. M., Silva, A. A., Pérez-Escamilla, R., & Kac, G. (2013). Household food insecurity and excess weight/obesity among Brazilian women and children: a life-course approach. *Cad Saude Publica, 29*(2), 219-226.

Serdula, M. K., Ivery, D., Coates, R. J., Freedman, D. S., Williamson, D. F., & Byers, T. (1993). Do obese children cecome cbese adults? a review of the literature. *Prev Med, 22*(2), 167-177.

Shalitin, S., Abrahami, M., Lilos, P., & Phillip, M. (2005). Insulin resistance and impaired glucose tolerance in obese children and adolescents referred to a tertiary-care center in Israel. *Int J Obes (Lond), 29*(6), 571-578.

Shang, L., O'Loughlin, J., Tremblay, A., & Gray-Donald, K. (2014). The association between food patterns and adiposity among Canadian children at risk of overweight. *Appl Physiol Nutr Metab, 39*(2), 195-201.

Sorof, J., & Daniels, S. (2002). Obesity hypertension in children: A problem of epidemic proportions. *Hypertension, 40*(4), 441-447.

Stice, E., & Durant, S. (2014). Elevated objectively measured but not self-reported energy intake predicts future weight gain in adolescents. *Appetite, 81*, 84-88.

Tanner, J. M. (1965). *The relationship of puberty to other maturity indicators and body composition in man*. Paper presented at the Symposia of the Society for the Study of Human Biology.

Torun, B. (2005). Energy requirements of children and adolescents. *Public Health Nutr, 8*(7A), 968-993.

USDA. (2012). U.S. household food security survey module: six-item short form economic research service, USDA. Retrieved Oct 3rd, 2015, from: http://www.ers.usda.gov/datafiles/Food_Security_in_the_United_States/Food_Security_Survey_Modules/short2012.pdf

Welk, G. J., Corbin, C. B., & Dale, D. (2000). Measurement issues in the assessment of physical activity in children. *Res Q Exerc Sport, 71*(2), S59-73.

WHO. (2013). BMI-for-age (5-19 years). Retrieved May 20th, 2016, from: http://www.who.int/growthref/who2007_bmi_for_age/en/

WHO. (2015a). BMI classification. Retrieved May 10th, 2016, from: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html

WHO. (2015b). Growth reference 5-19 years, height-for-age (5-19 years). Retrieved May 20th, 2016, from: http://www.who.int/growthref/who2007_height_for_age/en/

Wrotniak, B. H., Epstein, L. H., Paluch, R. A., & Roemmich, J. N. (2004). Parent weight change as a predictor of child weight change in family-based behavioral obesity treatment. *Arch Pediatr Adolesc Med, 158*(4), 342-347.

Xuereb, G., Johnson, P., Morris, A., Bocage, C., Trotter, P., & Henry, F. (2001). Obesity in Caribbean children: its magnitude and current control efforts. *CFNI, 34*, 120-126.

Zephirin, & Manuelita, P. (1990). *Manual of Nutrition and Dietetic Practice for the Caribbean*: CFNI, PAHO, WHO.

Table 1. Baseline demographic characteristics of children and their caregivers by children's baseline weight status (n=336)

	Thin (n=14)	**Healthy weight (n=248)**	**Overweight (n=45)**	**Obese (n=29)**	***p***
Children					
Age, mean ± SD	7.3 ± 0.82	7.4 ± 0.94	7.3 ± 0.92	7.5 ± 0.95	0.906
Sex, female, %	14.3	48.8	48.9	48.3	0.065
HFA z-score, mean ± SD *	-0.12 ± 0.69[a]	0.26 ± 0.91[b]	0.99 ± 0.91[ab]	1.12 ±1.01[ab]	<0.001
Caregiver					
Age, mean ± SD	35.6 ± 10.4	34.5 ± 9.5	34.8 ± 9.1	39.6 ± 10.4	0.068
Sex, female, %	93.3	95.4	98.7	96.6	0.501
Unmarried, %	57.1	46.2	57.6	69.2	0.762
BMI, mean ± SD	36.9 ± 6.9	40.1 ± 9.5	40.1 ± 8.3	41.9 ± 6.9	0.396
Household food insecurity, %	50.0	48.3	56.8	75.0	0.054
Country, Trinidad, %	86.0	52.4	57.8	58.6	0.396
Education, < secondary, %	43.8	43.8	52.5	35.3	0.501

* Indicate significance at the 0.001 levels
[a, b] different superscripts indicate statistically different means

Table 2. Children's weight status at baseline and follow-up (n=336)

	Thin	**Healthy weight**	**Overweight**	**Obese**	***p***
Baseline	14 (4.17)	248 (73.8)	45 (13.4)	29 (8.63)	<0.001
Follow-up	15 (4.46)	225 (67.0)	44 (13.1)	52 (15.5)	

Numbers in the table are n (%)

Table 3. Dietary intake by change in weight category of school-aged children 6-12 years in two Caribbean countries (n=321)*

	Children who did not move up a weight category (n=275)	**Children who became overweight or obese (n=46)**	***p***
Energy, kcal	1943 ± 702	1803 ± 744	0.164
Carbohydrate, g	288 ± 111	269 ± 119	0.259
Protein, g	62.9 ± 31.3	62.2 ± 26.6	0.995
Fat, g	62.8 ± 33.7	57.0 ± 30.5	0.263
Total sugar, g	118 ± 66.1	110 ± 72.7	0.253
Fiber, g	14.6 ± 7.74	13.7 ± 7.43	0.414
Calcium, mg	655 ± 406	636 ± 400	0.707
Iron, mg	14.3 ± 9.52	14.5 ± 9.82	0.788
Staple, portions	8.56 ± 5.47	7.48 ± 4.13	0.288
Foods from animals, portions	4.21 ± 3.52	4.56 ± 3.38	0.515
Legumes and nuts, portions	0.24 ± 0.72	0.17 ± 0.45	0.722
Fruits, portions	1.14 ± 2.15	0.57 ± 1.10	0.002
Vegetables, portions	1.11 ± 1.56	1.25 ± 1.39	0.187

* Thin children were excluded

Table 4. Multiple regression model of association with adiposity (n=336)

	Beta estimate	**SE**	***p***
Age	0.17	0.08	0.043
Baseline BMI z-score	0.43	0.06	<0.001
Baseline HFA z-score	0.20	0.08	0.016
R-square	0.21		

Table 5. Children's change in adiposity by baseline quartiles of BMI z-score (n=336)

	1st quartile	**2nd quartile**	**3rd quartile**	**4th quartile**	***p***
Number of children	83	85	85	83	<0.001
Adiposity change (BMI adjusted)	0.68 ± 1.3 [a]	1.1 ± 1.1 [b]	1.2 ± 1.5 [c]	2.5 ± 1.6 [d]	

***** Adjustment for age was done by subtracting the sex–age-specific median BMI
[a, b, c, d] different superscripts indicate statistically different means

BRIDGING STATEMENT

In chapter 4, it was established that the prevalence of overweight and obesity is rapidly increasing among Caribbean school-aged children. This increase was observed over only an 18 month period. Predictors of an increased level of adiposity (BMI adjusted for age and sex) of children were the increasing age of the children, their initial level of adiposity, and their height. Food insecurity did not have an association with this increase in adiposity, and dietary predictors of weight gain were not apparent. The balance of physical activity and energy intake is challenging to measure so it is unclear whether diet or physical activity, which tends to decrease, as children were getting heavier, might have been responsible for this increase in overweight and obesity. It is clear from our data that the excessive weight gain in some children is not related to food security.

In addition to weight measures, which reflect the quantity of food consumed in relation to activity, we were interested in markers of micronutrient deficiency that might reflect the longer-term dietary intake of food insecure children. Anemia is a health concern among children in the Caribbean. While the prevalence of anemia among children in English-speaking Caribbean countries is unknown, there have been some estimates made and some very out of date studies. These studies indicate high rates of anemia. The quality of the diet, including protein and iron is a concern for children in developing countries. In addition to dietary data, measuring diet quality is important for examining micronutrient deficiencies and trying to understand the reasons for any deficiencies so as to ameliorate the situation. Thus, in the third study (Chapter 5), anemia prevalence and its correlates were investigated.

CHAPTER V. ANEMIA AND ITS CORRELATES AMONG SCHOOL-AGED CHILDREN IN TWO CARIBBEAN COUNTRIES

Authors

1. Walaa A. Mumena, Ph.D. Candidate, School of Dietetics and Human Nutrition, McGill University, Sainte-Anne-de-Bellevue, Québec, Canada
2. Isabella Francis-Granderson, Principle Investigator of the CARICOM food security project, Faculty of Food and Agriculture, University of the West Indies, St. Augustine Campus, Trinidad and Tobago
3. Leroy E. Phillip, Principle Investigator of the CARICOM food security project, Department of Animal Science, McGill University, Sainte-Anne-de-Bellevue, Québec, Canada
4. Katherine Gray-Donald, School of Dietetics and Human Nutrition, McGill University, Sainte-Anne-de-Bellevue, Québec, Canada

5.1. Abstract

Background: Anemia is highly prevalent among children in developing countries, with iron deficiency anemia reported to be the most common form. The extent of anemia in the Caribbean is unknown. This study aimed to investigate the prevalence and the correlates of anemia among school-aged children in two Eglish-speaking Caribbean countries.

Methods: This study included 331 children aged 7-12 years and their caregivers, recruited in 2013-14 from eight schools in Trinidad and Tobago and seven schools in St. Kitts and Nevis. Hemoglobin level was measured using a finger prick blood test analysed by HemoCue. A single 24-hour dietary recall as well as height and weight measures were collected from the children. Household food security was measured using the 18-item U.S. Household Food Security Survey Module of the USDA.

Results: The overall prevalence of anemia, using race-specific cut-offs, was 30%. Anemia was more prevalent among children living in food insecure than food secure households (39% vs. 23%, p=0.002). Dietary intakes of anemic children were similar to those non-anemic. More than half (56%) of anemic children's iron intake was coming from plant sources, while animal protein sources contributed 18% of the total iron consumed, and 14% and 12% of the iron consumed came from mixed foods and supplements, respectively. Food sources of iron were not related to anemia status. Household food insecurity was associated with lower hemoglobin levels among children, but age, sex and BMI z-score were not related to hemoglobin levels.

Conclusion: Anemia is highly prevalent among children in the investigated Caribbean countries, especially among children living in food insecure households. Collecting more iron indicators can help in understaning the causes of this condition. This study found no evidence of dietary differences that might explain the link between food insecurity and anemia.

5.2. Introduction

Anemia is a public health concern, particularly among young children and women in developing countries (ACC/SCN, 2000; WHO, 2013). Children may be negatively affected by anemia in terms of their cognitive performance and growth (Bandhu, Shankar, & Tandon, 2003; WHO, 2013b). The prevalence of anemia is higher among school-aged children in developing countries as compared to developed countries, at 53% vs. 10%, respectively (ACC/SCN, 2000). Although the prevalence of anemia among school-aged children in developing countries is particularly high, a very limited number of studies have been conducted concerning this problem within this age group. A number of countries still have little or no data regarding anemia; thus, the World Health Organization (WHO) has made estimates of the levels of anemia in these settings (WHO & CDC, 2008). In the Caribbean, data regarding the prevalence of anemia are very limited and outdated (Mujica-Coopman et al., 2015; Simmons & Gurney, 1982).

Age and sex are important factors that need to be considered when assessing anemia among school-aged children. Before the age of 12 years, girls tend to have a higher hemoglobin concentration as compared to boys (Gibson, 2005). In addition, race also has an effect on hemoglobin levels, as it has been shown that individuals of African descent tend to have a lower hemoglobin concentration as compared to Caucasians, after controlling for iron deficiency status, age and income (Gibson, 2005). This difference is due to genetic factors that control differences in the globin protein (United States Department of the Air Force & United States Department of the Army, 1973). Also, obesity has been linked to anemia, as a higher prevalence of iron deficiency anemia has been observed among obese children (Sharif, Madani, & Tabatabaie, 2014).

Since the type of iron consumed can affect the efficiency of iron absorption (Tapiero, Gate, & Tew, 2001), concerns have been expressed regarding the quality of the protein consumed by children in developing countries (Millward & Jackson, 2004; Neumann, Harris, & Rogers, 2002). However, no data are available on the intake of iron or the sources of iron consumed by children living in these countries.

In the Caribbean region, where data are lacking, childhood anemia continues to be a public health concern. This study aims to provide an estimate of the prevalence of anemia and to examine the correlates of this condition in relation to the types of food consumed, obesity and food insecurity.

5.3. Methods

This study was part of the food and nutrition security project in the Caribbean region. The nutrition component of this project aimed to improve the dietary and nutritional status of children in the Caribbean through school feeding programs. Aspects of the project have been previously reported (Phillip & Francis-Granderson, 2014). Ethical approvals were obtained from the McGill Ethics Review Board, as well as from the Ministries of Education and the Ministries of Health in Trinidad and Tobago and St. Kitts and Nevis. Data for this study were collected between September 2013 and April 2014. Children aged 7-12 years and their caregivers were recruited from eight schools in Trinidad and Tobago and seven schools in St. Kitts and Nevis. Schools in Trinidad were selected from those with a high proportion of children who consumed the government supplied school lunch, which is offered to the children of families in need. Schools in St. Kitts, where all children are offered a free lunch, were selected from rural areas near the capital. A letter requesting caregiver and child participation was sent home. Children with signed parental consent forms were enrolled in this study. In cases where families had more than one child in the age range, the participant child was randomly chosen. Trained personnel collected blood samples, anthropometric measures and a single 24-hour dietary recall for each participating child. Demographic variables, including the caregiver's age, sex, ethnicity/race and education were also collected.

A nurse performed a finger prick blood test to measure hemoglobin level by HemoCue. Children's height was measured as standing height using a wall-mounted stadiometer and body weight was measured using a digital floor scale. Height and weight were used to calculate body mass index (BMI) z-score according to the WHO criteria. A single 24-hour dietary recall was completed during a home interview with the child and his/her caregiver, as recommended to improve the accuracy of reported dietary intake (Eck, Klesges, & Hanson, 1989). Caregivers and their children were asked to provide details of the types and amounts of foods that were consumed by the child on the previous day. Portion models (Santé Quebec, Montreal, Canada) were used to help estimate amounts consumed in milliliters and were converted to grams for data entry for each food item. CANDAT Nutrient Analysis Software (Godin London Incorporated, London, ON) was used for the nutrient analysis, which was based on the Canadian Nutrition Files released in 2010 (Health Canada, 2007a). For local food products, labels or local recipes were used to estimate nutrient content. Foods groups were formed based on the Six Caribbean Food Groups (staples (including staples and ground provisions), legumes and nuts, foods from animals (including meats and milk), fruits, vegetables, fats and oils) (Zephirin & Manuelita, 1990). Portions of foods followed Canada's Food Guide (Health Canada, 2007b). Detailed information regarding serving sizes is provided in **Appendix B**. Also, iron sources were divided into animal protein, plant-based protein, mixed foods and supplements. This was done by grouping food codes from the Canadian Nutrient File based on their source of iron and analyzing nutrient intake by food group. Vitamin and mineral supplements taken on the day of the 24-hour dietary recall were included in the nutrient intake values, and iron from supplements were grouped separately.

5.4. Statistical analysis

The WHO cut-off point for hemoglobin for identifying anemia among children aged 5-11 years has been set at <11.5 g/dL, while for children at the age of 12 years the cut-off has been set at <12 g/dL (WHO & CDC, 2008). Race-specific cut-offs for individuals of African descent of <10.5 g/dL and <11.0 g/dL, for children aged 5-11 and 12 years, respectively, were used as recommended by the WHO/UNICEF/UNU (Gibson, 2005; Johnson-Spear & Yip, 1994), thus this race-adjusted cut-off was used for children of African descent.

Dietary intake among children was examined in relation to anemia (based on race-specific cut-offs). To minimize the problem of only measuring of one day’s dietary intake, the mean for each group (anemic vs. non-anemic) was used, as the mean intake of the group is a good representation of the of group’s diet (Beaton et al., 1979), while it cannot measure usual intake for individuals.

The 18-item U.S. Household Food Security Survey Module of the USDA, which was validated in this study, was used to classify adult and child food security status, as well as that of the household (USDA, 2012). Household food security status was categorized according to USDA procedures as high (raw score of zero), marginal (raw score 1-2), low (raw score of 3-7) and very low food security (raw score > 8) for households with children, in order to identify food security groups at the household level. Households belonging to the high or marginal food security groups were combined as “food secure” households. Similarly, households with a low or very low food security status were combined to make the “food insecure” group. In addition, child-specific food security status was categorized as high or marginal (raw score 0-1), low (raw score 2-4), or very low (raw score ≥ 5) as spesified by the USDA (USDA, 2012).

Multiple regression analysis was performed to examine the relationship between age, sex (boy=1, girl=2), iron intake, household food insecurity (food secure=0, food insecure=1), education (less than secondary=0, secondary or more=1) and ethnicity (Afro-Caribbean=1, other=0) as correlates of hemoglobin level. All statistical tests were 2-tailed, and the significance level was $p < 0.05$. The Bonferroni method was used to correct for the multiple comparisons of dietary intake performed in this study. Statistical analysis was performed using SAS® software version 9.4 (2013, SAS Institute Inc., Cary, NC, USA).

5.5. Results

Data from a total of 331 children were included in the final analysis. All children with missing dietary, anthropometric or hemoglobin level data (11.1%, n=62), as well as children with very high hemoglobin levels (>20 mg/L) (2.2%, n=12) were excluded. The mean ± SD hemoglobin level of children aged 7-12 years included in this study was 11.7 ± 1.40 g/dL. The distribution of hemoglobin levels is shown in **Figure 1.** The prevalence of anemia among children aged 7-12 years, using the race-specific cut-off, was 29.9%, which was similar across countries (27.0% in Trinidad and Tobago vs. 32.4% in St. Kitts and Nevis). There were no differences in children's age, sex or BMI z-score, the caregiver's age, sex or education level, or household size in relation to anemia status. Household food insecurity was the only variable associated with a higher prevalence of anemia, as shown in **Table 1**. The mean intakes of protein and iron of anemic children were 1.61 g/kg and 11.9 ± 9.96 mg, respectively. No differences were found between the dietary intake of anemic and non-anemic children, as shown in **Table 2**. Furthermore, food sources of iron were not linked to anemia. Anemic children consumed 18% of their iron from animal protein sources as compared to 17% for non-anemic children, while plant-based protein contributed 56% vs. 60% of iron for anemic and non-anemic children, respectively. Mixed foods contributed 14% vs. 13% of iron for anemic and non-anemic children, respectively. Seven percent of children used supplements that contained iron, which contributed 12% and 10% of the iron consumed by anemic and non-anemic children, respectively.

Regression analysis was performed using the children's age, sex, BMI z-score, household food security status, iron intake, caregiver education and ethnicity as correlates of hemoglobin level. In this multivariate model, the only two correlates of hemoglobin level were food insecurity and being of African origin, while age, sex, BMI z-score, iron intake and caregiver education level were not associated with hemoglobin levels, as shown in **Table 3**.

5.6. Discussion

Anemia is highly prevalent among the study sample of children aged 7-12 years and was more prevalent among children from food insecure households. Also, household food insecurity and being of African origin were the only correlates to lower hemoglobin levels.

Hemoglobin was used as the only measure to assess anemia in this study. In some studies conducted in developing countries, which aimed to determine iron deficiency anemia prevalence, hemoglobin was used to assess anemia and serum ferritin was used to assess iron deficiency (Keikhaei, Zandian, Ghasemi, & Tabibi, 2007). In other developing country studies, hemoglobin was the only measure used (Cavalcanti, Vasconcelos, Muniz, Santos, & Osório, 2014; Jatav, Kumbhare, Rao, Reddy, & Chennamaneni, 2014). Larger studies of children in the U.S. and China have used more sensitive measures to assess the correlates of iron deficiency, including free erythrocyte protoporphyrin and serum ferritin (Halterman, Kaczorowski, Aligne, Auinger, & Szilagyi, 2001; Zhu, Liao, & Collaborative Study Group for "The Epidemiological Survey of

Iron Deficiency in Children in China, 2004). However, these studies did not investigate the causes of anemia.

Hemoglobin concentration is largely affected by race. A study conducted to compare the hematologic differences between healthy adult African-Americans and Caucasians found that hemoglobin concentration for African-Americans was lower than Caucasians (matched for age and sex and Caucasians served as controls). This study recommended using race-specific standards for hemoglobin when assessing anemia among individuals of African descent (Beutler & West, 2005). Since this recommendation is rarely applied (Desai et al., 2005; Ehrhardt et al., 2006), the anemia prevalence among individuals of African descent is often overestimated. When anemia prevalence is determined among individuals of African descent, the WHO/UNICEF/UNU recommend reducing the hemoglobin cut-off by 1 g/dL (Gibson, 2005; Johnson-Spear & Yip, 1994). In this study, race was adjusted through the use of race-specific cut-off points.

Anemia was associated with household food insecurity. This finding is in line with the findings of previous studies, which conducted among toddlers in India and the U.S. (Pasricha et al., 2010; Skalicky et al., 2006), while among older American children an association between anemia and food insecurity was only found among children aged 12-15 years (Eicher-Miller, Mason, Weaver, McCabe, & Boushey, 2009). This association between anemia and food insecurity might be due to the smaller quantities of meats consumed by children living in food insecure households (Matheson, Varady, Varady, & Killen, 2002). Mean protein and iron intakes of anemic children were above the Dietary Reference Intake (DRI) (EAR of 0.76 g/kg/d for protein for children aged 4-13 years; EAR for iron of 4.1 mg/d for children aged 4-8 years, 5.9 mg/d for males aged 9-13 years and 5.7 mg/d for females aged 9-13 years) (Institute of

Medicine, 2001; Institute of Medicine, 2005). Considering that these children consume an average of 18% of from animal-sourced foods per day (which is comparable to consumption patterns in developed countries), one would expect a lower prevalence of anemia based on the diet, which is certainly mixed.

Previous studies have reported a positive association between iron intake and hemoglobin levels among infants in their first year (Lind et al., 2004). The link between iron intake and hemoglobin levels was found among older children in Europe to exist only when supplements were consumed (Gunnarsson, Thorsdottir, & Palsson, 2007). In our study, anemia was not associated with any dietary indicators, including protein, iron and vitamin C. The iron intake from animal protein sources was similar among anemic and non-anemic children.

The strengths of this study are its large sample size and the availability of dietary intake information. Also, the availability of data regarding iron sources betters our understanding of the quality of iron consumed by children in developing countries. One of the limitations of this study was the use of a capillary blood sample test by HemoCue. Capillary blood sample assessed by HemoCue is less sensitive and thus more likely to underestimate anemia prevalence than a venous blood sample 84, but it provides an adequate estimate (specificity 93). Lower sensitivity in a capillary sample could be due to dilution of the sample through interstitial fluid or could be due to a number of factors including biological variation in hemoglobin concentrations (Neufeld et al., 2002). A more sensitive measure is needed to assess hemoglobin level in order to investigate the association between hemoglobin and its correlates. The use of hemoglobin blood tests alone limits the ability to assess iron status. Thus, the use of multiple indicators, including serum ferritin, serum iron, total iron binding capacity (TIBC) and transferrin saturation, is recommended for assessing iron deficiency (Gibson, 2005). Also, in this study we did not have information regarding the history of blood diseases, such as sickle cell anemia, which is prevalent in the Caribbean population (National Heart Lung and Blood Insititute, 2012). This study also is limited in term of its generalizability to the Caribbean population, as children were recruited in Trinidad from schools with a high proportion of children who participated in the free lunch program. Also, the use of only one 24-hour dietary recall limited the ability to determine the usual intake of foods and nutrients that are strongly linked to anemia status.

In conclusion, anemia is highly prevalent among the school-aged children studied in the Caribbean and the prevalence was higher among the children from food insecure households. It is possible that the dietary data used in this study suffered from misreporting, which made it challenging to detect the association between dietary intake, including iron intake, and anemia, or there may be other reasons why children living in food insecure households are more likely to be anemic. Given the prevalence of anemia among children in food insecure households, a study of anemia that includes measures of iron sufficiency and more advanced measures of dietary intake is warranted to protect the health of children.

5.7. References

ACC/SCN. (2000). Fourth report on the world nutrition situation. Retrieved Nov 10th, 2015, from: http://www.unscn.org/layout/modules/resources/files/rwns4.pdf

Bandhu, R., Shankar, N., & Tandon, O. P. (2003). Effect of iron on growth in iron deficient anemic school going children. *Indian J Physiol Pharmacol, 47*(1), 59-66.

Beaton, G. H., Milner, J., Corey, P., McGuire, V., Cousins, M., Stewart, E., . . . Little, J. A. (1979). Sources of variance in 24-hour dietary recall data: implications for nutrition study design and interpretation. *Am J Clin Nutr, 32*(12), 2546-2559.

Beutler, E., & West, C. (2005). Hematologic differences between African-Americans and whites: the roles of iron deficiency and α-thalassemia on hemoglobin levels and mean corpuscular volume. *Blood, 106*(2), 740-745.

Cavalcanti, D. S., Vasconcelos, P. N., Muniz, V. M., Santos, N. F., & Osório, M. M. (2014). Iron intake and its association with iron-deficiency anemia in agricultural workers' families from the Zona da Mata of Pernambuco, Brazil. *Rev Nutr, 27*(2), 217-227.

Desai, M. R., Terlouw, D. J., Kwena, A. M., Phillips-Howard, P. A., Kariuki, S. K., Wannemuehler, K. A., . . . Ter Kuile, F. O. (2005). Factors associated with hemoglobin concentrations in preschool children in Western Kenya: cross-sectional studies. *Am J Trop Med Hyg, 72*(1), 47-59.

Eck, L. H., Klesges, R. C., & Hanson, C. L. (1989). Recall of a child's intake from one meal: are parents accurate? *J Am Diet Assoc, 89*, 784-787.

Ehrhardt, S., Burchard, G. D., Mantel, C., Cramer, J. P., Kaiser, S., Kubo, M., . . . Mockenhaupt, F. P. (2006). Malaria, anemia, and malnutrition in African children defining intervention priorities. *J Infect Dis, 194*(1), 108-114.

Eicher-Miller, H. A., Mason, A. C., Weaver, C. M., McCabe, G. P., & Boushey, C. J. (2009). Food insecurity is associated with iron deficiency anemia in U.S. adolescents. *Am J Clin Nutr, 90*(5), 1358-1371.

Gibson, R. S. (2005). *Principles of nutritional assessment* (2nd ed.). New York: Oxford University Press.

Gunnarsson, B. S., Thorsdottir, I., & Palsson, G. (2007). Associations of iron status with dietary and other factors in 6-year-old children. *Eur J Clin Nutr, 61*(3), 398-403.

Halterman, J. S., Kaczorowski, J. M., Aligne, C. A., Auinger, P., & Szilagyi, P. G. (2001). Iron deficiency and cognitive achievement among school-aged children and adolescents in the United States. *Pediatrics, 107*(6), 1381-1386.

Health Canada. (2007a). Food and nutrition, the Canadian nutrient file. Retrieved Oct 6th, 2015, from: http://www.hc-sc.gc.ca/fn-an/nutrition/fiche-nutri-data/cnf_aboutus-aproposdenous_fcen-eng.php

Health Canada. (2007b). Food and nutrition, what is a food guide serving? Retrieved Sep 15th, 2015, from: http://www.hc-sc.gc.ca/fn-an/food-guide-aliment/basics-base/serving-portion-eng.php

Institute of Medicine. (2001). *Dietary reference intakes for vitamin a, vitamin k, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc: a report of the panel on micronutrients*. Washington, D.C.: National Academies Press.

Institute of Medicine Food and Nutrition Board. (2005). *Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids*. Washington, D.C.: The National Academies Press.

Jatav, R. K., Kumbhare, M. B., Rao, P. R., Reddy, A. K., & Chennamaneni, R. (2014). Anemia: a non-communicable disease, its prevalence in adult patients of Telangana region of South India; A semi-urban tertiary care teaching hospital study. *Int J Adv Med, 1*(1), 9-12.

Johnson-Spear, M. A., & Yip, R. (1994). Hemoglobin difference between black and white women with comparable iron status: justification for race-specific anemia criteria. *Am J Clin Nutr, 60*(1), 117-121.

Keikhaei, B., Zandian, K., Ghasemi, A., & Tabibi, R. (2007). Iron-deficiency anemia among children in southwest Iran. *Food Nutr Bull, 28*(4), 406-411.

Lind, T., Hernell, O., Lönnerdal, B., Stenlund, H., Domellöf, M., & Persson, L. A. (2004). Dietary iron intake is positively associated with hemoglobin concentration during infancy but not during the second year of life. *J Nutr, 134*(5), 1064-1070.

Matheson, D. M., Varady, J., Varady, A., & Killen, J. D. (2002). Household food security and nutritional status of Hispanic children in the fifth grade. *Am J Clin Nutr, 76*(1), 210-217.

Millward, D. J., & Jackson, A. A. (2004). Protein/energy ratios of current diets in developed and developing countries compared with a safe protein/energy ratio: Implications for recommended protein and amino acid intakes. *Public Health Nutr, 7*(3), 387-405.

Mujica-Coopman, M. F., Brito, A., López de Romaña, D., R´ıos-Castillo, I., Cori, H., & Olivares, M. (2015). Prevalence of anemia in Latin America and the Caribbean. *Food Nutr Bull, 36*(2), S119-128.

National Heart Lung and Blood Insititute. (2012). Who is at risk for sickle cell anemia? *Sickle cell anemia.* Retrieved Sep 15th, 2015, from: http://www.nhlbi.nih.gov/health/health-topics/topics/sca/atrisk.html

Neufeld, L., García-Guerra, A., Sánchez-Francia, D., Newton-Sánchez, O., Ramírez-Villalobos, M. D., & Rivera-Dommarco, J. (2002). Hemoglobin measured by Hemocue and a reference method in venous and capillary blood: a validation study. *Salud Publica Mex, 44*(3), 219-227.

Neumann, C., Harris, D. M., & Rogers, L. M. (2002). Contribution of animal source foods in improving diet quality and function in children in the developing world. *Nutrition Research, 22*(1), 193-220.

Pasricha, S. R., Black, J., Muthayya, S., Shet, A., Bhat, V., Nagaraj, S., . . . Shet, A. S. (2010). Determinants of anemia among young children in rural India. *Pediatrics, 126*(1), 140-149.

Phillip, L. E., & Francis-Granderson, I. (2014). *Improving the nutrition and health of CARICOM populations: final technical report (March 2011 - August 2014)*. Retrieved Sep 15th, 2015, from: https://idl-bnc.idrc.ca/dspace/handle/10625/53596

Sharif, M. R., Madani, M., & Tabatabaie, F. (2014). Comparative evaluation of iron deficiency among obese and non-obese children. *Iran J Ped Hematol Oncol, 4*(4), 160-166.

Simmons, W. K., & Gurney, J. M. (1982). Nutritional anemia in the English-speaking Caribbean and Suriname. *Am J Clin Nutr, 35*(2), 327-337.

Skalicky, A., Meyers, A. F., Adams, W. G., Yang, Z., Cook, J. T., & Frank, D. A. (2006). Child food insecurity and iron deficiency anemia in low-income infants and toddlers in the United States. *Matern Child Health J, 10*(2), 177-185.

Tapiero, H., Gate, L., & Tew, K. D. (2001). Iron: deficiencies and requirements. *Biomed Pharmacother, 55*(6), 324-332.

USDA. (2012). U.S. household food security survey module: three-stage design, with screeners, Economic Research Service, USDA. Retrieved Oct 15th, 2014, from: http://www.ers.usda.gov/datafiles/Food_Security_in_the_United_States/Food_Security_Survey_Modules/hh2012.pdf

WHO. (2013). Micronutrient deficiencies, iron deficiency anaemia. Retrieved Aug 20th, 2015, from: http://www.who.int/nutrition/topics/ida/en/

WHO, & CDC. (2008). Worldwide prevelence of anaemia 1993-2005: WHO global database on anaemia. Retrieved Sep 13rd, 2015, from: http://apps.who.int/iris/bitstream/10665/43894/1/9789241596657_eng.pdf

Zephirin, & Manuelita, P. (1990). *Manual of Nutrition and Dietetic Practice for the Caribbean*: CFNI, PAHO, WHO.

Zhu, Y. P., Liao, Q. K., & Collaborative Study Group for "The Epidemiological Survey of Iron Deficiency in Children in China. (2004). Prevalence of iron deficiency in children aged 7 months to 7 years in China. *Zhonghua Er Ke Za Zhi, 42*(12), 886-891.

Figure 1. Hemoglobin distribution of primary school children aged 7-12 in Trinidad and Tobago and St. Kitts and Nevis (n=331)

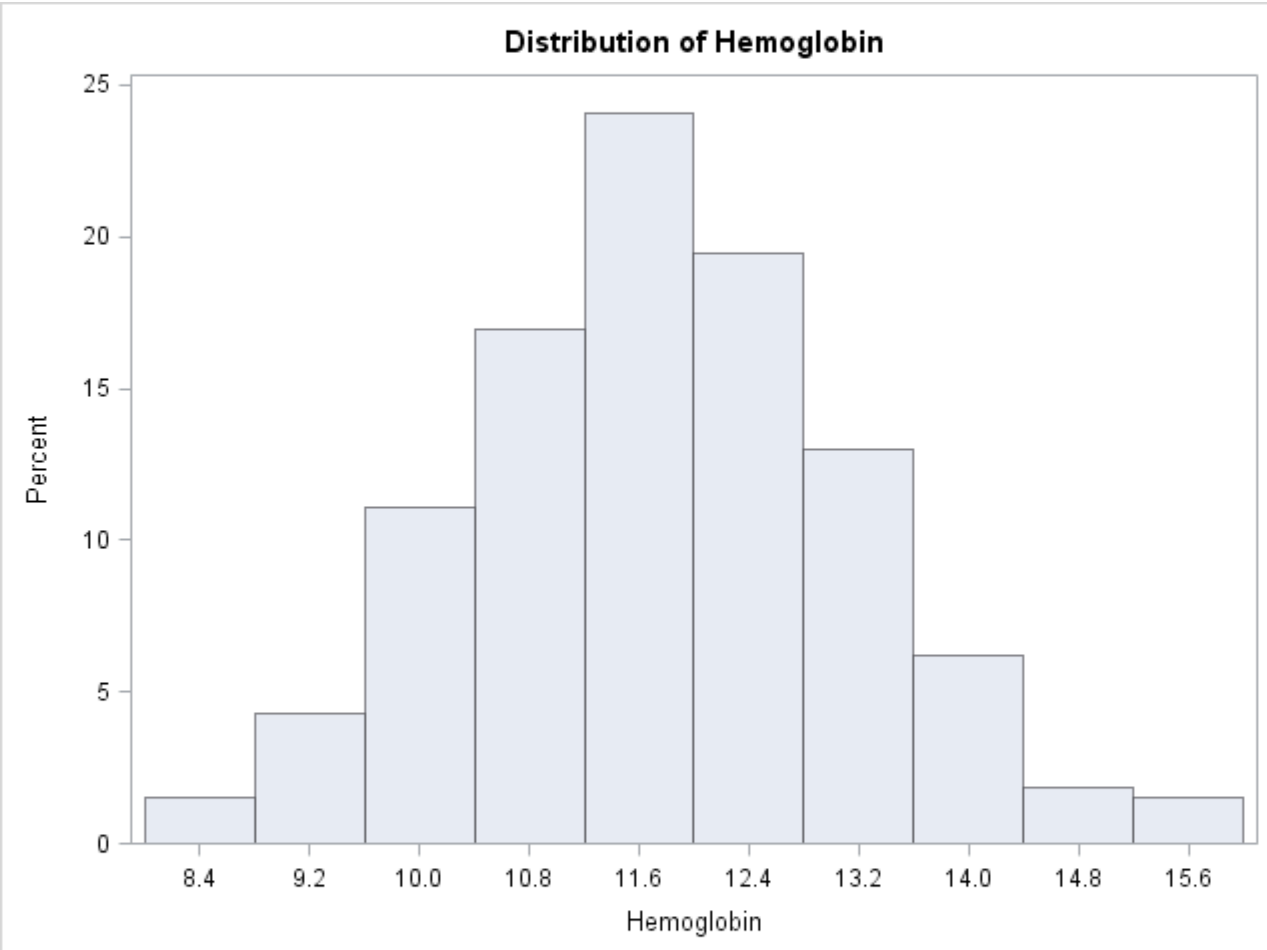


Table 1. Demographic characteristics by anemia status in children aged 7-12 and their caregivers in Trinidad and Tobago and St. Kitts and Nevis (n=331)

	Anemic (n=99)	**Non-anemic (n= 232)**	***p***
Children			
Hemoglobin g/dL[1] *	10.0 ± 0.73	12.3 ± 1.6	<0.001
Age years[1]	9.30 ± 1.05	9.25 ± 1.08	0.681
Sex, Girls[2]	53.4	53.3	0.991
Weight kg[1]	35.2 ± 11.2	35.3 ± 10.4	0.952
BMI z-score[1]	0.28 ± 1.63	0.42 ± 1.40	0.294
HFA z-score[1]	0.42 ± 1.07	0.42 ± 1.08	0.994
Caregiver			
Age years[1]	36.1 ± 8.76	35.6 ± 9.28	0.406
Sex, Female[2]	95.7	93.5	0.560
Ethnicity[2]			
Afro-Caribbean*	55.8	72.0	0.006
Indo-Caribbean	11.6	4.40	
Mixed	32.6	23.6	
Country, Trinidad[2]	32.4	67.6	0.393
Food insecurity[2]			
Household*	39.0	61.0	0.002
Children	35.9	64.1	0.155
Family size[1]	5.01 ± 1.72	5.26 ± 1.78	0.232
Education, less than secondary[2]	47.7	43.7	0.817

[1] mean ± SD
[2] %
* Indicates significant at 0.01 level after Bonferoni correction

Table 2. Dietary intake of children aged 7-12 in Trinidad and Tobago and St. Kitts and Nevis by anemia status (n=331)

	Anemic (n=99)	**Non-anemic (n=232)**	***p***
Staples, portions	5.1 ± 3.0	5.3 ± 3.1	0.999
Foods from animals, portions	2.2 ± 1.5	2.3 ± 1.5	0.536
Legume and nuts, portions	0.30 ± 0.64	0.20 ± 0.44	0.311
Fruits, portions	1.2 ± 1.7	0.91 ± 1.4	0.352
Vegetables, portions	0.61 ± 0.99	0.55 ± 0.90	0.673
Energy, kcal	1637 ± 595	1731 ± 656	0.638
Carbohydrate, g	246 ± 102	249 ± 101	0.784
Protein, g	56.0 ± 27.8	57.7 ± 30.8	0.553
Fat, g	49.9 ± 25.4	57.3 ± 31.5	0.303
Fiber, g	11.5 ± 7.0	10.9 ± 5.7	0.794
Calcium, mg	513 ± 372	531 ± 364	0.661
Iron, mg	11.9 ± 9.96	11.7 ± 7.6	0.897
B_{12}, ug	2.4 ± 2.7	2.6 ± 4.7	0.847
Potassium, mg	1505 ± 806	1503 ± 700	0.800
Vitamin C, mg	195 ± 164	176 ± 172	0.200
Zinc, mg	6.7 ± 3.8	7.21 ± 5.0	0.224
Total sugar, g	104 ± 60.3	103 ± 56.0	0.867

Note: Numbers are mean ± SD

Table 3. Regression analysis of correlates of hemoglobin levels among children aged 7-12 in Trinidad and Tobago and St. Kitts and Nevis (n=279)

	Beta estimate	**SE**	***p***
Age	0.06	0.09	0.534
Sex (boy=1, girl=2)	0.18	0.17	0.276
BMI z-score	0.08	0.06	0.218
Iron mg	-0.01	0.01	0.166
Food security (food secure=0, food insecure=1)	-0.46	0.17	0.008
Education (less than secondary=0, secondary or more=1)	-0.24	0.25	0.351
Ethnicity/race (Afro=1, other=0)	-0.40	0.19	0.036
R-square	0.06		

CHAPTER VI. ADDITIONAL ANALYSES

In this chapter, the Ph.D. candidate includes baseline analyses that were not included in the previous three studies. Data regarding household food security and wealth status in relation to diet and household meat supplies were examined.

6.1. Methods

The baseline data from Trinidad were used to investigate household food security, household wealth, household food expenditures, children's dietary intake and anthropometrics measures. Household food security was assessed using an adapted version of the United States Department of Agriculture (USDA) Household Food Security Scale. The responses to this six-item short form of the Food Security Survey Module were used to classify household food security status, which was validated within the Caribbean (Gulliford, Mahabir, & Rocke, 2004). The Household Basic Needs questionnaire was used to develop a wealth index. Questions regarding dwelling description, including about dwelling materials (walls, floors, roof), number of rooms in the dwelling (to examine crowding), ownership of the dwelling and the main source of drinking water, as well as telephone, mobile and Internet accessibility, were used to determine household wealth status. Questionnaire items were given a score based on their value in a Caribbean setting (from 0 to 4). A weighted measure was applied using the Principle Component Analysis (PCA) to create the wealth index, which typically follows a basic form:

$$A_i = b_1 \cdot a_{1i} + b_2 \cdot a_{2i} + ... + b_k \cdot a_{ki} \qquad \text{(Filmer \& Scott, 2008)}$$

where A_i is the wealth index for household "i", (a_{1i}, $a_{2i,}$, .. ,a_{ki}) are k indicators of asset ownership and housing quality variables, and (b_1, b_2, ... , b_k) are weights used to aggregate the indicators into an index.

Height and weight were measured to determine the children's BMI z-scores. A single 24-hour dietary recall was used with each child to assess dietary intake. Dietary data were explained in detail previously in Chapter 3. A food expenditure questionnaire was used to determine food quantities purchased by each household during the previous 30 days. The recorded amount of Trinidadian dollars spent on each item was used to estimate the quantity of the item purchased. The Consumer Price Index (2010) for Trinidad was used as an estimation of food prices. The data were used to calculate food quantities for meats only, as a considerable amount of fruits and vegetables were received from other sources, such as through the school lunch program or as a gift. Money spent on meats (excluding beef, due to its rare use) was used to calculate the quantities of meats purchased for the household.

6.2. Statistical analysis

The PCA was used to create the wealth index. Households in the lowest quartile of the wealth index (not wealthy) were compared to all other households (wealthy) by dietary intake. The mean intakes of children in wealthy and not wealthy households were compared using t-test. The WHO cut-off points for weight categories are: severe thinness, $< -3SD$; thinness, $< -2SD$; overweight, $>1SD$; and obesity, $>2SD$ (WHO, 2015).

Analysis of Variance (ANOVA) was used to compare the means of the various groups and Chi-square tests were used to compare proportions. All statistical tests were 2-tailed, and the significance level was $p < 0.05$. Statistical analysis was performed using SAS® software version 9.4 (2013, SAS Institute Inc., Cary, NC, USA).

6.3. Results

A total of 314 children were included in this analysis. The prevalence of household food insecurity was 43.1%. Household food insecurity was linked only to a lower intake of protein (62.4 ± 29.0 g vs. 68.4 ± 33.7 g, $p = 0.041$) in the subset of data only from Trinidad.

A number of the variables measured in the household basic needs questions had similarly low variability. Wealth status was not linked to children's dietary intake or growth. In fact, the lowest wealth score was not indicative of greater food insecurity.

Data from the food expenditure questionnaire showed that, over a 30-day period, chicken was the meat most commonly purchased by food secure and food insecure households (12.8 ± 8.40 kg vs. 10.7 ± 7.89 kg, $p = 0.08$, respectively). Mean quantities of pork and fish purchased by food secure households in the previous 30 days were significantly higher as compared to the quantities purchased by food insecure households (pork: 0.94 kg± 1.73 kg vs. 0.67 kg ± 1.55 kg, $p = 0.04$; fish: 1.65 kg ± 1.59 kg vs. 0.86 kg ± 1.24 kg, $p < 0.0001$; salted fish: 0.65 kg ± 0.66 kg vs. 0.55 kg ± 0.67 kg, $p = 0.05$). In contrast, there were no differences regarding the purchase of canned fish (0.41 ± 0.55 kg vs. 0.35 ± 0.50 kg, $p = 0.37$), hot dogs (0.91 ± 1.15 kg vs. 0.70 ± 0.89 kg, $p = 0.10$) and eggs (1.41 kg ± 1.30 kg vs. 1.42 kg ± 1.37 kg, $p = 0.92$), as shown in **Figure 1**.

6.4. Discussion

In this study, additional analyses showed that food insecurity was associated with a lower intake of protein, as well as lower household purchases of pork and fish in Trinidad. Neither household food security nor our estimate of wealth was linked to children's weight status.

This study's finding of low protein intakes among food insecure children might be linked to the lower consumption of meats among these food insecure children. Specifically, food insecure households reported lower purchases of pork and fish (higher quality meats) as compared to food secure households. Our wealth measure did not differentiate those who were food insecure from those who were food secure, and more suitable questions for assessing household basic needs are required for this setting. Some variables such as cellphone use were almost ubiquitous and thus could not contribute to the wealth score.

The results of this research project are in line with those of previous studies which have reported lower intakes of protein and household purchases of meats among food insecure individuals (Hackett, Zubieta, Hernandez, & Melgar-Quiñonez, 2007; Matheson, Varady, Varady, & Killen, 2002). The research shows that the quality of the protein consumed by children should be of greater concern than the quantity, since, in this study the amount of protein consumed by children in food insecure households exceeded the recommendations. The data shows that food insecure households had lower supplies of protein that are high in iron bioavailability, including pork and fish.

In previous studies, wealth status has been linked to dietary diversity and children's growth in developing countries (Gunnsteinsson et al., 2010; Hong, Banta, & Betancourt, 2006). In a prospective study conducted among children from Peru and Vietnam, overweight and obesity were more prevalent among children from the top quartile of wealth (Carrillo-Larco, Miranda, & Bernabé-Ortiz, 2015). In this study, however, wealth status did not predict diet or the nutritional health of the children, as the sample was relatively small and homogeneous in terms of household basic needs. In this study, food security was not associated with overweight/obesity or growth. Similar findings have been reported in studies conducted in wealthier settings (Bhargava, Jolliffe, & Howard, 2008; Bhattacharya, Currie, & Haider, 2004).

In conclusion, household food insecurity was marginally linked to diet and household meat purchases, but the wealth index was not linked to diet, the growth of school-aged children in Trinidad, or household meat purchases.

6.5. References

Bhargava, A., Jolliffe, D., & Howard, L. L. (2008). Socio-Economic, behavioural and environmental factors predicted body weights and household food insecurity scores in the early childhood longitudinal study-kindergarten. *Br J Nutr, 100*(2), 438-444.

Bhattacharya, J., Currie, J., & Haider, S. (2004). Poverty, food insecurity, and nutritional outcomes in children and adults. *J Health Econ, 23*(4), 839-862.

Carrillo-Larco, R. M., Miranda, J. J., & Bernabé-Ortiz, A. (2015). Wealth index and risk of childhood overweight and obesity: Evidence from four prospective cohorts in Peru and Vietnam. *Int J Public Health*, 1-11.

Filmer, D., & Scott, K. (2008). Assessing asset indices, policy research working paper 4605 (policy research working paper 4605). Retrieved Aug 20th, 2015, from: http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2008/04/21/000158349_20080421130829/Rendered/PDF/WPS4605.pdf

Gulliford, M. C., Mahabir, D., & Rocke, B. (2004). Reliability and validity of a short form household food security scale in a Caribbean community. *BMC Public Health, 4*(22).

Gunnsteinsson, S., Labrique, A. B., West, K. P., Christian, P., Mehra, S., Shamim, A.-A., . . . Klemm, R. D. (2010). Constructing indices of rural living standards in Northwestern Bangladesh. *J Health Popul Nutr, 28*(5), 509-519.

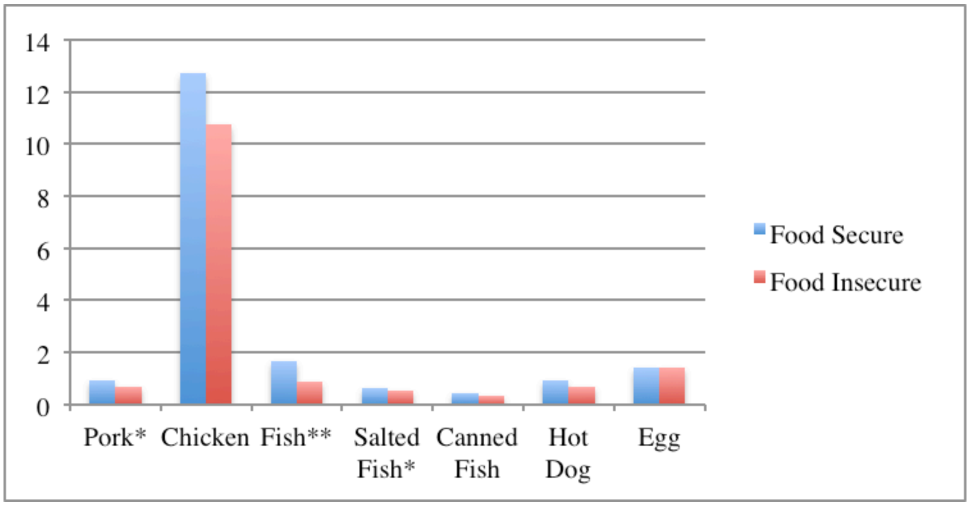
Hackett, M., Zubieta, A. C., Hernandez, K., & Melgar-Quiñonez, H. (2007). Food insecurity and household food supplies in rural Ecuador. *Arch Latinoam Nutr, 57*(1), 10-17.

Hong, R., Banta, J. E., & Betancourt, J. A. (2006). Relationship between household wealth inequality and chronic childhood under-nutrition in Bangladesh. *Int J Equity Health, 5*(15).

Matheson, D. M., Varady, J., Varady, A., & Killen, J. D. (2002). Household food security and nutritional status of Hispanic children in the fifth grade. *Am J Clin Nutr, 76*(1), 210-217.

WHO. (2015). Growth reference 5-19 years, height-for-age (5-19 years). Retrieved May 20th, 2015, from: http://www.who.int/growthref/who2007_height_for_age/en/

Figure 1. Household purchasing differences of selected types of meat by kilograms in food secure and food insecure settings in Trinidad



*, ** Indicates significance at the 95%, and 99% level, respectively.
The Consumer Price Index (2010) was used to estimate quantities purchased from total money spent on each item during the last 30 days, units are in kilograms.
Consumer price data were not available for other food groups.

CHAPTER VII. SUMMARY AND CONCLUSION

This research was motivated by concerns expressed by the governments of numerous Caribbean countries regarding food insecurity. The effect of food insecurity on children's nutritional health in the Caribbean region was unknown, but a negative effect on nutritional health was expected. In other regions of the world, food insecurity has been shown to have a negative effect on children's diets. However, studies have found that children's growth has only been affected by food insecurity in less advantaged settings. This research was also motivated by an interest in the links between food insecurity and childhood obesity, and food insecurity and anemia, since obesity and anemia are two other major health concerns in developing countries.

The doctoral candidate and her supervisor established the study objectives concerning food insecurity and its effect on the nutritional health of children in two Caribbean countries, Trinidad and Tobago and St. Kitts and Nevis. Demographic variables, anthropometric measures, food security data, dietary intake data and blood samples were collected via the Community Health and Nutrition Household Survey (CHS) for 390 children and their caregivers. These data were collected at two time points; baseline data were collected between January and July 2012, and follow-up data between September 2013 and April 2014.

The CARICOM food security project, "From Farm to Fork," included a school-based nutrition intervention, which involved an educational intervention and menu modification. This intervention aimed to improve children's diets and prevent increased obesity. For this particular research project, however, the aim was not to assess the outcomes of this intervention. Principles and evaluation of the intervention were described in detail in the IDRC's report, which showed that this intervention had only a small effect on children's intake of fruits and vegetables (Phillip & Francis-Granderson, 2014).

Food security has been measured differently in different settings (Cordeiro, Monego, & Martins, 2014; Metallinos-Katsaras, Must, & Gorman, 2012; Statistics Canada, 2015; USDA, 2015). In this study, both baseline and follow-up data on food security and dietary intake were measured. The follow-up data were the main data used in this thesis, as food security at follow-up was assessed using the 18-item U.S. Household Food Security Survey Module of the USDA, which was validated in this study. The 18-item module is a more precise measure of food security as compared to the six-item short form, which was used at baseline. The 18-item module measures food security at the adult, child and household levels, and has been found to be a stable, robust, and reliable measurement tool (Bickel, Nord, Price, Hamilton, & Cook, 2000). In the second study, due to the longitudinal design and because food insecurity was not a main predictor of BMI z-score, baseline data for food security were used.

This study reported a prevalence of household food insecurity of 46% and 42% at baseline and at follow-up, respectively, and child food insecurity was 27% at follow-up. At follow-up, a higher prevalence of food insecurity was reported in St. Kitts and Nevis as compared to Trinidad and Tobago, at both household and child levels. This study provided evidence that food insecurity at the household level was linked to lower household purchases of high quality protein (pork and fish), lower protein and zinc intakes, as well as higher rates of anemia (using race-specific cut-offs), but not associated with obesity or any growth parameters.

Previous research has shown a link between food insecurity and low diet quality, regardless of a country's level of income and development (Kendall, Olson, & Frongillo, 1996; Kirkpatrick & Tarasuk, 2008; Mark, Lambert, O'Loughlin, & Gray-Donald, 2012; Matheson, Varady, Varady, & Killen, 2002). In addition, the relationship between food insecurity and growth among less wealthy populations has been outlined in other studies (Cordeiro, Wilde, Semu, & Levinson, 2012; Hackett, Melgar-Quinonez, & Alvarez, 2009; Isanaka, Mora-Plazas, Lopez-Arana, Baylin, & Villamor, 2007; Matheson, Varady, Varady, & Killen, 2002; Metallinos-Katsaras et al., 2012).

In this study, important associations between food insecurity, diet and growth were lacking. The lack of associations may be a reflection of the support that these children receive in terms of free school lunches, which all contain a daily serving of meat and staples, with some vegetables on occasion. The lunches provide approximately 30% of the children's daily nutrients, which may be of assistance to food insecure households. In Trinidad, some children also receive a free breakfast.

Previous studies have found a positive association between food insecurity and anemia among populations in both developed and developing countries (Eicher-Miller, Mason, Weaver, McCabe, & Boushey, 2009; Pasricha et al., 2010). This study also reported a positive association between anemia and household food insecurity. The higher prevalence of anemia among children from food insecure households may be explained by the lower protein intake and lower household purchases of high quality foods in the "meat" group (pork and fish).

In this study, the prevalence of overweight is far higher than underweight and there is virtually no stunting. The children were gaining more weight as they aged than one would expect based on the growth reference and this was particularly evident for the heaviest children. One of the predictors of overweight and weight gain commonly found in previous studies was parental overweight. In this study, this was not shown to be a predictor, but virtually all of the mothers or caregivers were overweight and many were obese.

Dietary intake was not linked to changes in adiposity, but this lack of association could be explained by the misreporting of energy intake. While this study did not examine the types of foods that were under-reported, previous studies have found that carbohydrates (mostly sugars) are commonly under-reported in adults (Lissner & Lindroos, 1994; Poppitt, Swann, Black, & Prentice, 1998). Also, a review suggested that food items with a negative health image (e.g. cakes, sweets and confectionary), which are high in added sugars and fats, are commonly under-reported (Macdiarmid & Blundell, 1998). Among European children, under-reporting was more prevalent among girls and it was associated with low socioeconomic status, high BMI and high protein intake and low intake of simple carbohydrate (Börnhorst et al., 2013; Lioret et al., 2011; Sichert-Hellert, Kersting, & Schöch, 1998).

The anemia prevalence after adjusting for race was high (29.9%) among children aged 7-12 years. This study reported an association between hemoglobin level and race (children of African descent tend to have lower hemoglobin levels). Race was adjusted for among children of African descent, as recommended by the WHO when classifying the data as anemic or not. Anemia has been considered to be a more serious health concern among children of a younger age, even though the prevalence of anemia has been shown to be higher among school-aged children (ACC/SCN, 2000). Data regarding anemia among school-aged children are lacking, and data provided by the WHO for school-aged children in a number of developing countries, including the Caribbean, are only estimates determined by regression models (WHO & CDC, 2008).

One of the strengths of this thesis is its relatively large sample size. This study used the gold standard approach, Cole et al.'s approach, to estimate changes in adiposity of children in a longitudinal manner. Also, this study takes into account the problem of under-reporting. To limit the effect of under-reporting when examining predictors of increased children's adiposity, misreporting was adjusted for based on Goldberg cut-offs (Black, 2000).

In this thesis, the sample was not representative of the general population, as data in Trinidad were collected from schools with a high proportion of children enrolled in the school lunch program, which offered free lunches to the children of all families in need. Thus, the prevalence figures do not indicate national prevalence and only give an idea about the prevalence among this sample. Also, dietary intake data were limited, as only a single 24-hour dietary recall was collected for each child. Thus, dietary adequacy and usual intake were not estimated due to the unavailability of internal or within-person variability. The number of days required to assess an individual's usual intake is dependent on the day-to-day variability of the nutrient, but it is difficult and costly to collect data for multiple days in developing countries (Burrows, Martin, & Collins, 2010; Willett, 2012). Physical activity level is an important determinant of children's changes in adiposity. In this study, however, physical activity levels were not considered in the analyses due to accuracy concerns. Children's physical activity levels were measured by a self-reported questionnaire, but most physical activities of school-aged children in the Caribbean countries examined are unstructured, so the data obtained by the questionnaire was not reflective of the children's true levels of physical activity. A useful tool to assess physical activity in epidemiological studies among children is the accelerometer (Plasqui, Bonomi, & Westerterp, 2013), but a lack of resources and the concentration on dietary measures limited the ability to use accelerometers to measure children's physical activity levels in this study.

Prior to this study, food insecurity had never been investigated in relation to diet, growth, obesity and anemia among children in the Caribbean. The high prevalence of obesity and food insecurity, and food insecurity's relation to anemia, point to the urgent need to improve the dietary and food security status of the Caribbean population. This study advances the understanding of the anemia problem, but better iron indicators could help to develop an understanding of why some children have anemia despite a diet that is not low in nutrients on average.

There is a lack of nutritional data in the Caribbean, and many previous studies are no longer relevant given the global rise in obesity. The increased prevalence of overweight and obesity observed in this 18-month study points to the seriousness of this health problem among children and highlights the need to give careful attention to what foods are offered in schools. Diet quality among school-aged children and the foods offered in schools in the Caribbean require further investigation, particularly with respect to the rapid rise in obesity and the potential problem of anemia. While the nutritional problems related to food insecurity are not of great magnitude, it remains that many families, including children to some extent, are not secure in terms of their ability to access appropriate foods.

7.1. References

ACC/SCN. (2000). Fourth report on the world nutrition situation. Retrieved Nov 10th, 2015, from: http://www.unscn.org/layout/modules/resources/files/rwns4.pdf

Bickel, G., Nord, M., Price, C., Hamilton, W., & Cook, J. (2000). Guide to measuring household food security. Retrieved Nov 20th, 2015, from:http://www.fns.usda.gov/sites/default/files/FSGuide.pdf

Black, A. E. (2000). The sensitivity and specificity of the Goldberg cut-off for EI:BMR for identifying diet reports of poor validity. *Eur J Clin Nutr, 54*(5), 395-404.

Börnhorst, C., Huybrechts, I., Ahrens, W., Eiben, G., Michels, N., Pala, V., . . . IDEFICS consortium. (2013). Prevalence and determinants of misreporting among European children in proxy-reported 24 h dietary recalls. *Br J Nutr, 109*(7), 1257-65.

Burrows, T. L., Martin, R. J., & Collins, C. E. (2010). A systematic review of the validity of dietary assessment methods in children when compared with the method of doubly labeled water. *J Am Diet Assoc, 110*(10), 1501-1510.

Cordeiro, L. S., Wilde, P. E., Semu, H., & Levinson, F. J. (2012). Household food security is inversely associated with undernutrition among adolescents from Kilosa, Tanzania. *J Nutr, 142*(9), 1741-1747.

Cordeiro, M. M., Monego, E. T., & Martins, K. A. (2014). Overweight in Goiás'quilombola students and food insecurity in their families. *SciELO, 27*(4), 405-412.

Eicher-Miller, H. A., Mason, A. C., Weaver, C. M., McCabe, G. P., & Boushey, C. J. (2009). Food insecurity is associated with iron deficiency anemia in US adolescents. *Am J Clin Nutr, 90*(5), 1358-1371.

Hackett, M., Melgar-Quinonez, H., & Alvarez, M. C. (2009). Household food insecurity associated with stunting and underweight among preschool children in Antioquia, Colombia. *Rev Panam Salud Publica, 25*(6), 506-510.

Isanaka, S., Mora-Plazas, M., Lopez-Arana, S., Baylin, A., & Villamor, E. (2007). Food insecurity is highly prevalent and predicts underweight but not overweight in adults and school children from Bogotá, Colombia. *J Nutr, 137*(12), 2747-2755.

Kendall, A., Olson, C. M., & Frongillo, E. A. (1996). Relationship of hunger and food insecurity to food availability and consumption. *J Am Diet Assoc, 96*(10), 1019-1024;

Kirkpatrick, S. I., & Tarasuk, V. (2008). Food insecurity is associated with nutrient inadequacies among Canadian adults and adolescents. *J Nutr, 138*(3), 9.

Lioret, S., Touvier, M., Balin, M., Huybrechts, I., Dubuisson, C., Dufour, A., . . . Lafay, L. (2011). Characteristics of energy under-reporting in children and adolescents. *Br J Nutr, 105*(11), 1671-80.

Lissner, L., & Lindroos, A. K. (1994). Is dietary underreporting macronutrient-specific? *Eur J Clin Nutr, 48*(6), 453-454.

Macdiarmid, J., & Blundell, J. (1998). Assessing dietary intake: who, what and why of under-reporting. *Nutr Res Rev, 11*(2), 231-253.

Mark, S., Lambert, M., O'Loughlin, J., & Gray-Donald, K. (2012). Household income, food insecurity and nutrition in Canadian youth *Can J Public Health, 103*(2), 94-99.

Matheson, D. M., Varady, J., Varady, A., & Killen, J. D. (2002). Household food security and nutritional status of Hispanic children in the fifth grade. *Am J Clin Nutr, 76*(1), 210-217.

Metallinos-Katsaras, E., Must, A., & Gorman, K. (2012). A longitudinal study of food insecurity on obesity in preschool children. *J Acad Nutr Diet, 112*(12), 1949-1958.

Pasricha, S. R., Black, J., Muthayya, S., Shet, A., Bhat, V., Nagaraj, S., . . . Shet, A. S. (2010). Determinants of anemia among young children in rural India. *Pediatrics, 126*(1), 140-149.

Phillip, L. E., & Francis-Granderson, I. (2014). *Improving the nutrition and health of CARICOM populations:final technical report (March 2011 - August 2014)*. Retrieved Nov 15th, 2015, from: https://idl-bnc.idrc.ca/dspace/handle/10625/53596

Plasqui, G., Bonomi, A. G., & Westerterp, K. R. (2013). Daily physical activity assessment with accelerometers: new insights and validation studies. *Obes Rev, 14*(6), 451-462.

Poppitt, S. D., Swann, D., Black, A. E., & Prentice, A. M. (1998). Assessment of selective under-reporting of food intake by both obese and non-obese women in a metabolic facility. *Int J Obes Relat Metab Disord, 22*(4), 303-311.

Sichert-Hellert, W., Kersting, M., & Schöch, G. (1998). Underreporting of energy intake in 1 to 18 year old German children and adolescents. *Z Ernahrungswiss, 37*(3), 242-51.

Statistics Canada. (2015). *Health at a glance, food insecurity in Canada*. Retrieved April 10th, 2010, from: http://www.statcan.gc.ca/pub/82-624-x/2015001/article/14138-eng.pdf.

USDA. (2015). Food security in the U.S., key statistics and graphics. Retrieved Nov 21st, 2015, from: http://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/key-statistics-graphics.aspx

WHO, & CDC. (2008). Worldwide prevelence of anaemia 1993-2005: WHO global database on anaemia. Retrieved Sep 13th, 2015, from: http://apps.who.int/iris/bitstream/10665/43894/1/9789241596657_eng.pdf

Willett, W. (2012). *Nutritional epidemiology* (3rd ed. Vol. 40). New York, NY: Oxford University Press.

APPENDICES

APPENDIX A: U.S. HOUSEHOLD FOOD SECURITY SURVEY MODULE

U.S. HOUSEHOLD FOOD SECURITY SURVEY MODULE:
THREE-STAGE DESIGN, WITH SCREENERS
Economic Research Service, USDA
September 2012

Revision Notes: The food security questions are essentially unchanged from those in the original module first implemented in 1995 and described previously in this document.

September 2012:

- Corrected skip specifications in AD5
- Added coding specifications for "How many days" for 30-day version of AD1a and AD5a.

July 2008:

- Wording of resource constraint in AD2 was corrected to, "…because there wasn't enough money for food" to be consistent with the intention of the September 2006 revision.
- Corrected errors in "Coding Responses" Section

September 2006:

- Minor changes were introduced to standardize wording of the resource constraint in most questions to read, "…because there wasn't enough money for food."
- Question order was changed to group the child-referenced questions following the household- and adult-referenced questions. The Committee on National Statistics panel that reviewed the food security measurement methods in 2004-06 recommended this change to reduce cognitive burden on respondents. Conforming changes in screening specifications were also made. NOTE: Question numbers were revised to reflect the new question order.
- Follow up questions to the food sufficiency question (HH1) that were included in earlier versions of the module have been omitted.
- User notes following the questionnaire have been revised to be consistent with current practice and with new labels for ranges of food security and food insecurity introduced by USDA in 2006.

Transition into Module (administered to all households):
These next questions are about the food eaten in your household in the last 12 months, since (current month) of last year and whether you were able to afford the food you need.

Optional USDA Food Sufficiency Question/Screener: Question HH1 (This question is optional. It is not used to calculate any of the food security scales. It may be used in conjunction with income as a preliminary screener to reduce respondent burden for high income households).

HH1. [IF ONE PERSON IN HOUSEHOLD, USE "I" IN PARENTHETICALS, OTHERWISE, USE "WE."]

Which of these statements best describes the food eaten in your household in the last 12 months: —enough of the kinds of food (I/we) want to eat; —enough, but not always the kinds of food (I/we) want; —sometimes not enough to eat; or, —often not enough to eat?

[1] Enough of the kinds of food we want to eat
[2] Enough but not always the kinds of food we want
[3] Sometimes not enough to eat
[4] Often not enough to eat
[ ] DK or Refused

Household Stage 1: Questions HH2-HH4 (asked of all households; begin scale items).

[IF SINGLE ADULT IN HOUSEHOLD, USE "I," "MY," AND "YOU" IN PARENTHETICALS; OTHERWISE, USE "WE," "OUR," AND "YOUR HOUSEHOLD."]

HH2. Now I'm going to read you several statements that people have made about their food situation. For these statements, please tell me whether the statement was often true, sometimes true, or never true for (you/your household) in the last 12 months—that is, since last (name of current month).

The first statement is "(I/We) worried whether (my/our) food would run out before (I/we) got money to buy more." Was that often true, sometimes true, or never true for (you/your household) in the last 12 months?

[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

HH3. "The food that (I/we) bought just didn't last, and (I/we) didn't have money to get more." Was that often, sometimes, or never true for (you/your household) in the last 12 months?

[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

HH4. "(I/we) couldn't afford to eat balanced meals." Was that often, sometimes, or never true for (you/your household) in the last 12 months?

[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

<u>Screener for Stage 2 Adult-Referenced Questions:</u> If affirmative response (i.e., "often true" or "sometimes true") to one or more of Questions HH2-HH4, OR, response [3] or [4] to question HH1 (if administered), then continue to ***Adult Stage 2;*** otherwise, if children under age 18 are present in the household, skip to ***Child Stage 1,*** otherwise skip to ***End of Food Security Module.***

<u>NOTE:</u> In a sample similar to that of the general U.S. population, about 20 percent of households (45 percent of households with incomes less than 185 percent of poverty line) will pass this screen and continue to Adult Stage 2.

<u>Adult Stage 2: Questions AD1-AD4</u> (asked of households passing the screener for Stage 2 adult-referenced questions).

AD1. In the last 12 months, since last (name of current month), did (you/you or other adults in your household) ever cut the size of your meals or skip meals because there wasn't enough money for food?

[ ] Yes
[ ] No (Skip AD1a)
[ ] DK (Skip AD1a)

AD1a. [IF YES ABOVE, ASK] How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?

[ ] Almost every month
[ ] Some months but not every month
[ ] Only 1 or 2 months
[ ] DK

AD2. In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food?

[ ] Yes
[ ] No
[ ] DK

AD3. In the last 12 months, were you every hungry but didn't eat because there wasn't enough money for food?

[ ] Yes
[ ] No
[ ] DK

AD4. In the last 12 months, did you lose weight because there wasn't enough money for food?

[ ] Yes
[ ] No
[ ] DK

Screener for Stage 3 Adult-Referenced Questions: If affirmative response to one or more of questions AD1 through AD4, then continue to ***Adult Stage 3;*** otherwise, if children under age 18 are present in the household, skip to ***Child Stage 1,*** otherwise skip to ***End of Food Security Module.***

NOTE: In a sample similar to that of the general U.S. population, about 8 percent of households (20 percent of households with incomes less than 185 percent of poverty line) will pass this screen and continue to Adult Stage 3.

Adult Stage 3: Questions AD5-AD5a (asked of households passing screener for Stage 3 adult-referenced questions).

AD5. In the last 12 months, did (you/you or other adults in your household) ever not eat for a whole day because there wasn't enough money for food?

[ ] Yes
[ ] No (Skip AD5a)
[ ] DK (Skip AD5a)

AD5a. [IF YES ABOVE, ASK] How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?

[ ] Almost every month
[ ] Some months but not every month
[ ] Only 1 or 2 months
[ ] DK

Child Stage 1: Questions CH1-CH3 (Transitions and questions CH1 and CH2 are administered to all households with children under age 18) Households with no child under age 18, skip to ***End of Food Security Module.***

SELECT APPROPRIATE FILLS DEPENDING ON NUMBER OF ADULTS AND NUMBER OF CHILDREN IN THE HOUSEHOLD.

Transition into Child-Referenced Questions:
Now I'm going to read you several statements that people have made about the food situation of their children. For these statements, please tell me whether the statement was OFTEN true, SOMETIMES true, or NEVER true in the last 12 months for (your child/children living in the household who are under 18 years old).

CH1. "(I/we) relied on only a few kinds of low-cost food to feed (my/our) child/the children) because (I was/we were) running out of money to buy food." Was that often, sometimes, or never true for (you/your household) in the last 12 months?

[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

CH2. "(I/We) couldn't feed (my/our) child/the children) a balanced meal, because (I/we) couldn't afford that." Was that often, sometimes, or never true for (you/your household) in the last 12 months?

[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

CH3. "(My/Our child was/The children were) not eating enough because (I/we) just couldn't afford enough food." Was that often, sometimes, or never true for (you/your household) in the last 12 months?

[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

<u>Screener for Stage 2 Child Referenced Questions:</u> If affirmative response (i.e., "often true" or "sometimes true") to one or more of questions CH1-CH3, then continue to ***Child Stage 2;*** otherwise skip to ***End of Food Security Module.***

<u>NOTE:</u> In a sample similar to that of the general U.S. population, about 16 percent of households with children (35 percent of households with children with incomes less than 185 percent of poverty line) will pass this screen and continue to Child Stage 2.

<u>Child Stage 2: Questions CH4-CH7</u> (asked of households passing the screener for stage 2 child-referenced questions).
<u>NOTE:</u> In Current Population Survey Food Security Supplements, question CH6 precedes question CH5.

CH4. In the last 12 months, since (current month) of last year, did you ever cut the size of (your child's/any of the children's) meals because there wasn't enough money for food?

[ ] Yes
[ ] No
[ ] DK

CH5. In the last 12 months, did (CHILD'S NAME/any of the children) ever skip meals because there wasn't enough money for food?

[ ] Yes
[ ] No (Skip CH5a)
[ ] DK (Skip CH5a)

CH5a. [IF YES ABOVE ASK] How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?

[ ] Almost every month
[ ] Some months but not every month
[ ] Only 1 or 2 months
[ ] DK

CH6. In the last 12 months, (was your child/were the children) ever hungry but you just couldn't afford more food?

[ ] Yes
[ ] No
[ ] DK

CH7. In the last 12 months, did (your child/any of the children) ever not eat for a whole day because there wasn't enough money for food?

[ ] Yes
[ ] No
[ ] DK

END OF FOOD SECURITY MODULE
User Notes

(1) Coding Responses and Assessing Household Food Security Status:
Following is a brief overview of how to code responses and assess household food security status based on various standard scales. For detailed information on these procedures, refer to the *Guide to Measuring Household Food Security, Revised 2000,* and *Measuring Children's Food Security in U.S. Households, 1995-1999.* Both publications are available through the ERS Food Security in the United States Briefing Room.

Responses of "yes," "often," "sometimes," "almost every month," and "some months but not every month" are coded as affirmative. The sum of affirmative responses to a specified set of items is referred to as the household's raw score on the scale comprising those items.

- Questions HH2 through CH7 comprise the U.S. Household Food Security Scale (questions HH2 through AD5a for households with no child present). Specification of food security status depends on raw score and whether there are children in the household (i.e., whether responses to child-referenced questions are included in the raw score).
  - For households with one or more children:
    - Raw score zero—High food security
    - Raw score 1-2—Marginal food security
    - Raw score 3-7—Low food security
    - Raw score 8-18—Very low food security
  - For households with no child present:
    - Raw score zero—High food security
    - Raw score 1-2—Marginal food security
    - Raw score 3-5—Low food security
    - Raw score 6-10—Very low food security

  Households with high or marginal food security are classified as food secure. Those with low or very low food security are classified as food insecure.

- Questions HH2 through AD5a comprise the U.S. Adult Food Security Scale.
    - Raw score zero—High food security among adults
    - Raw score 1-2—Marginal food security among adults
    - Raw score 3-5—Low food security among adults
    - Raw score 6-10—Very low food security among adults

- Questions HH3 through AD3 comprise the six-item Short Module from which the Six-Item Food Security Scale can be calculated.
    - Raw score 0-1—High or marginal food security (raw score 1 may be considered marginal food security, but a large proportion of households that would be measured as having marginal food security using the household or adult scale will have raw score zero on the six-item scale)
    - Raw score 2-4—Low food security
    - Raw score 5-6—Very low food security

- Questions CH1 through CH7 comprise the U.S. Children's Food Security Scale.
    - Raw score 0-1—High or marginal food security among children (raw score 1 may be considered marginal food security, but it is not certain that all households with raw score zero have high food security among children because the scale does not include an assessment of the anxiety component of food insecurity)
    - Raw score 2-4—Low food security among children
    - Raw score 5-8—Very low food security among children

(2) Response Options: For interviewer-administered surveys, DK ("don't know") and "Refused" are blind responses—that is, they are not presented as response options, but marked if volunteered. For self-administered surveys, "don't know" is presented as a response option.

(3) Screening: The two levels of screening for adult-referenced questions and one level for child-referenced questions are provided for surveys in which it is considered important to reduce respondent burden. In pilot surveys intended to validate the module in a new cultural, linguistic, or survey context, screening should be avoided if possible and all questions should be administered to all respondents.

To further reduce burden for higher income respondents, a preliminary screener may be constructed using question HH1 along with a household income measure. Households with income above twice the poverty threshold, AND who respond <1> to question HH1 may be skipped to the end of the module and classified as food secure. Use of this preliminary screener reduces total burden in a survey with many higher-income households, and the cost, in terms of accuracy in identifying food-insecure households, is not great. However, research has shown that a small proportion of the higher income households screened out by this procedure will register food insecurity if administered the full module. If question HH1 is not needed for research purposes, a preferred strategy is to omit HH1 and administer Adult Stage 1 of the module to all households and Child Stage 1 of the module to all households with children.

(4) 30-Day Reference Period: The questionnaire items may be modified to a 30-day reference period by changing the "last 12-month" references to "last 30 days." In this case, items AD1a, AD5a, and CH5a must be changed to read as follows:

AD1a/AD5a/CH5a [IF YES ABOVE, ASK] In the last 30 days, how many days did this happen?

______ days

[ ] DK

Responses of 3 days or more are coded as "affirmative" responses.

APPENDIX B: FOOD SERVING SIZES

CFG category	Sub-category	Caribbean's Food Guide#	Comments
Staples	**Cereals**		
	Pasta /Rice/Other grains, cooked	½ cup (70 g)	
	Bread	1 slice (35 g)	
	Cold cereal	30 g	
	Hot cereal	3/4 cup (175 g)	
	Muffin (+sugar)	43 g	
	Pancake/Waffle(+fat)	32.5 g	(Ground provisions serving sizes were calculated based on carbohydrate content CHO~20g in 100g serving)
	Croissant(+fat)	45 g	
	Crackers/Grains, dry	20 g	
	Barley cooked/Bread stuffing	120 g	
	Starchy fruits, roots, tubers/ground provisions		
	Potatoes - fried	70 g	
	Potatoes – other	100 g	
	Sweet potato	100 g	
	Plantain	65 g	
	Green banana (1=115g)	90 g	
	Corn	110 g	
Legumes and Nuts	Legumes (e.g. beans)	175 g	
	Tofu	100 g	
	Nuts/Grains	124 g	
	Nut butters	30 g	
	Peas?	80 g	

Foods from Animals	Eggs	50 g	**Mixed dishes** • Cut-off for grain 10g/100g serving • Cut-off for protein 20g/100g serving
	Beef/	75 g	
	Veal/Lamb/Pork/Chicken/Fish/	75 g	
	Shellfish/Organ meats/Liver		
	Process meats (includes sausages	88 g	
	hotdogs, coldcuts and bacon)	68 g	
	Milk (including buttermilk)/Frozen Yogurt(+sugar)	1 cup (250 g)	
	Evaporated milk	1/2 cup (100 g)	
	Dry Milk	30 g	
	Milkshakes	600 g	
	Ice Cream (+fat+ sugar)/Ice Milk (+sugar)	400 g	
	Cottage cheese**	500 g	
	Other cheese	50 g	
	Yogurt	175 g	
	Cream Soups (made with milk)	520 g	
Vegetables	Dark green leafy vegetables (e.g. Callaloo, spinach, lettuce)		
	Raw	1 cup (55 g)	
	Cooked	1/2 cup (130 g)	
	Broccoli	90 g	
	Carrots	75 g	
	Other vegetables	85 g	
	Pumpkin/squash	115 g	
	Vegetable juices	128 g	
	Vegetable soup***	505 g	
	Tomatoes	240 g	
	Tomato sauce	100 g	
	Tomato paste	55 g	
	Mixed salad (lettuce, tomato)	138 g	
	Other salads	120 g	
Fruits	Apples, applesauce (1=128 g)	135 g	
	Bananas (1=115g)	150 g	
	Orange citrus fruit (1=151 g)	115 g	
	Grapefruit	235 g	
	Pears (1pear=169 g)	180 g	
	Peaches/Other fruit****	100 g	
	Dried fruit	15 g	
	Fruit juices (100% fruit)	120 g	
	Berries	70 g	

Fat and Oil	Oil Margarine Butter Salad dressing Coconut milk/cream Avocado	• Include a small amount of fat each day, 30 to 45 mL (2 to 3 Tbsp). • Limit butter, hard margarine, lard and shortening.	

Based on Canada's Food Guide to Healthy Eating in combination with weights obtained from The Good Health Eating Guide resource from the Canadian Diabetes Association
** Serving for cottage cheese based on amount of calcium in cheddar cheese
*** Vegetable soup calculated based on information found in Food Processor