Winter 12-15-2018

Understanding Adolescent Physical Activity in the Early Nutrition Transitioning Country of Haiti

Haley V. Becker
Washington University in St. Louis

WASHINGTON UNIVERSITY IN ST. LOUIS

George Warren Brown School of Social Work

Dissertation Examination Committee:
Lora Iannotti, Chair
Aaron Addison
Ross Brownson
Carolyn Lesorogol
Deborah Salvo
Rodrigo Siqueira-Reis

Understanding Adolescent Physical Activity in the Early Nutrition Transitioning Country of Haiti

by
Haley V. Becker

A dissertation presented to
The Graduate School
of Washington University in
partial fulfillment of the
requirements for the degree
of Doctor of Philosophy

December 2018
St. Louis, Missouri

Table of Contents

List of Figures

List of Tables

Acknowledgments

I have so many family, friends, mentors, and colleagues to thank for their constant love, encouragement, guidance, and—I mean this in the best way possible—distraction throughout this process. In so many ways, this degree is shared with all of you, as I literally would not have been able to do it without you. It takes a village, and I argue that I live in the best one. Thank you, thank you, thank you for being my people. I am incredibly blessed. There a too many to thank individually, but I would be remiss if I did not name a few in particular.

First and foremost, thank you to Lora Iannotti for giving me the opportunity to endeavor beyond my comfort zone and for guiding me as I discovered both a world of research and a population in which my career will forever be exciting and fulfilling. Thank you for your unending encouragement and guidance; I have reached both personal and professional milestones under your direction that I otherwise would never have achieved. I am eager to continue our shared goals for Haiti. I look forward to future collaborations and celebrated achievements together.

I owe a special debt of gratitude to Aaron Addison for encouraging my interests in GIS, classroom teaching, and world travel. Thank you for being my unofficial mentor. Thank you for helping me to hone my skills in guiding others through the learning process; you are an exemplary teacher and I've benefited from being your informal student for many years. I hope to continue our mentor-mentee relationship and friendship, as I still have so much to learn from you and I am excited for future experiences in the classroom and abroad.

I would also like to formally thank the rest of my dissertation committee. Your insights and direction molded this project into the best version of itself. I learned invaluable lessons about

collaboration, real-world application of research, understanding the “big picture” while under your supervision. You are all very busy and important people, so I am humbled and thankful that you took the time to help in this major academic and professional achievement.

Thank you to Bill Winston and Mollie Webb for your unflagging and always-patient help whenever I was out of my depth with GIS. You were always welcoming and supportive, and I will forever be grateful to you for helping me enhance my skills in a new field. It was a pleasure and an honor to work with you for the GIS User Group; I hope we stay connected through the user group for a long time to come.

A special thanks goes to Melissa Chapnick. You always had my back. Thank you for being my advocate, my calendar, my diary, and my friend. You did so much behind-the-scenes work to propel me through this process. You are inspiring in your work ethic, professionalism, and compassion. Thank you for all your work, for being a friendly face, and a kind ear whenever I need it.

Thank you to Vithya Murugan and Tess Thompson for being my peer mentors. You both generously offered me support, willingly answered my questions, and fondly shared my successes. I’m lucky my tenure at WashU overlapped with you two. These last few years would not have been the same without your guidance and friendship.

Thank you to Chien-Jen Chiang and Hyunil Kim for being my office buddies and friends. Also, thank you to Yu-Chih Chen, as you were our honorary office mate. All three of you helped me on a daily basis. You were there for the actual nitty gritty, ugly parts of graduate school. Your companionship assuaged my many moments of imposter syndrome. Your friendship encouraged me whenever I was frustrated. Your brilliance guided me whenever I was lost. I am

so happy we became friends. Thanks for being there for me and with me through the whole process.

Thank you to Allan Philippe and Sherlie Jean-Louis for your wisdom and patience while I ventured to a new place and got acquainted with Haiti and its people. You both gave me priceless direction and managed this project flawlessly. There is literally zero chance this project would have realized without your help. Thank you for being my ambassadors to Haiti. Thank you for being not just my colleagues, but also being my friends. You are forever in my heart.

I have to thank the people of Cap-Haïtien, Haiti for welcoming an outsider into their community. Thank you for teaching me. Thank you for protecting me, feeding me, and encouraging me when parts of this project felt insurmountable. Thank you for enriching my life forever. I am incredibly blessed and humbled to serve you. Thank you for trusting me to help your children. I promise to continue my work, putting them, Haiti, and the needs of all its people first. I promise to always listen first, act second, and let you guide me.

Thank you to Laura Krepp and Lauren Remspecher for being my unofficial copyeditors and dictionaries. Thank you for giving me your free time and knowledge. The further I advanced in this process, the more depleted my brain became regarding the rules of writing, language, and organization. You both helped me and laughed with me. You willingly listened while I talked through the jumbled analyses rattling in my brain and affirmed my abilities to actually organize them in a cohesive manner… sometimes helping me with grade-school level English language writing techniques. You both brought me back from the brink of quitting for the day so many times. Thank you for being my brilliant, brainy buddies.

Thanks to Rita Crowell, Julie Krummenacher, Diane Gorman, and Joann Reagan for being my other moms. You have all given me so much love, support, food, clothes, vacation,

fun, encouragement, laughter… the list goes on and on. You make my life richer, and this dissertation process was made easier so many times thanks you. I'm lucky that you are my family. Thank you for always being there for me.

Christy Wittich has earned an honorary doctorate throughout this process. There is no way to properly thank you for all your help and support. You did so much to help me, that I can't list it all here. Thank you for using your vacation days, free time, and money to come with me to Haiti and work with me in the field. You are truly an amazing friend! You kept me sane and you helped me have fun. You listened, processed, and gave invaluable feedback. I never felt alone in this process, because I always had you right by side. Thank you for being awesome—there is simply no other way to express how meaningfully contributed to my academic achievement. Thank you for being you!

I want to thank my life partner, Tom Reagan, for being my best friend throughout this process and all the rest of life. Thank you for being my unrelenting cheerleader. Thank you for your patience and kindness as I endeavored on the most challenging project in my life. Thank you for encouraging and supporting me while I explored life far away from you, and then for welcoming me home so lovingly each time my travels ended. Thank you for always believing that I could and would do this, and for making me believe it when I couldn't see the end of the road. Invariably, you were the reason I was able to reach another benchmark, stand up for myself, or overcome a hurdle. You are smarter, more professional, and more self-disciplined than I can ever hope to be. You have been the most positive influence in my adult life and I will forever love you for helping me be the best version of myself. I love you!

Finally, I must thank my parents, Marilyn and Nick Becker, for instilling in me the value of education from an early age. Thank you for always fostering my curiosity to understand how

the world works, answering all my random questions, encouraging my desire to learn both about and from those who are different from me, modeling compassion for others, and accepting my need to travel the world, all while always keeping my place at the table for when I got home. Thank you for believing me when I said I would be a doctor, guiding me to the best educational opportunities, pushing me to excel, and encouraging me. It took twenty-two years since I made my promise, but here I am! And it's because of you. This project would never have realized without your ongoing love and support. I have the coolest parents in the world. I love you forever!

Haley V. Becker

Washington University in St. Louis

December 2018

Dedicated to my parents: to my father, Nicholas J. Becker, to whom I made a promise; and to my mother, Marilyn K. Becker, without whom that promise would never have been fulfilled.

Abstract of the Dissertation

Understanding Adolescent Physical Activity in the Early Nutrition Transitioning Country of Haiti

by

Haley V. Becker

Doctor of Philosophy in Social Work

George Warren Brown School of Social Work

Washington University in St. Louis, 2018

Professor Lora Iannotti, Chair

The nutrition transition is underway in Haiti, giving rise to the dual burden of malnutrition. Physical activity (PA) plays an important role in mitigating the negative health consequences of nutrition transition and the dual burden, but heretofore this data has been unavailable for Haiti. This dissertation undertook an exploratory needs assessment providing baseline PA data for Haitian adolescents. It evaluated two different PA data collection methodologies: a cross-sectional survey adapted from the IPAQ long-form and objectively measured PA via Actigraph GT1M accelerometers. Next, it identified initial covariates of self-reported and objectively-assessed PA behaviors; data was operationalized as meeting the World Health Organization's recommendation (WHO REC) of ≥60 minutes of moderate or vigorous PA per day for children and adolescents. Finally, the study qualitatively examined the PA values, beliefs, and behaviors of adolescents via focus groups and structured observations. Survey and accelerometry data identified adolescent age, gender, dietary diversity and caregiver occupation as consistently significant covariates of meeting the WHO REC. Focus group and structured observation data

further emphasized gender differences in PA. Qualitative methods also revealed overweight to be considered desirable and beneficial, separating it from obesity, which was considered undesirable and associated with poor health. This study is the first of its kind, representing an important step in characterizing the link between the emergence of the dual burden of malnutrition and its risk factors in Haiti, as well as providing rationale for early adoption of policies and programs regarding PA, nutrition, and other types of assistance programming in Haiti.

Chapter 1: Background & Introduction

1.1 Problem Statement Introduction

The concepts of nutrition transition and the dual burden of malnutrition have been introduced over the past several decades.[1–8] Nutrition transition is comprised of changes in diet, food availability, and physical activity patterns as well as the combined effect of these changes on body composition. Typically, nutrition transitioning countries are simultaneously experiencing socioeconomic, demographic, and epidemiologic transitions.[1,9] The dual burden of malnutrition is highly documented in these same countries, characterized by the combination of underweight, stunted children/adolescents and overweight adults—often existing within the same household.[9,10] However, limited research examines the bimodal distribution of underweight/ stunting and overweight/obesity within the youth population of low- and middle-income countries (LMICs). This dissertation addresses a gap in the literature regarding the dual burden of malnutrition amongst school-age children and adolescents in low-resource settings, providing rationale for research and early intervention into the dual burden of malnutrition in this subpopulation.

The processes of LMICs' integration into the worldwide economic market (globalization) and accompanying population shifts from residence in rural to urban areas (urbanization) are catalysts of the aforementioned transitions. Collectively, these processes have led to socioeconomic gaps and accompanying shifts in the burden of disease distribution, characterized by a transition in higher prevalence rates of non-communicable diseases (NCDs) from high-income strata to low- and middle-income strata.[11–13] Globalization of food markets has made mass-produced, low-cost, high-energy-density foods more widely available in LMICs,

contributing to changes in dietary patterns that increase caloric consumption, but do not necessarily increase micronutrient consumption.[7,9,14] When these foods are consumed, the likelihood of hidden hunger occurs. Hidden hunger arises when food quality does not meet nutrient requirements, causing micronutrient deficiencies.[15] In more highly urbanized settings, the threat of hidden hunger is greatly increased: the threat of food scarcity is diminished, but the protective effects of family connectedness and subsistence agriculture are also diminished, contributing to increased consumption of these poor-quality, energy-dense, but cheap and affordable foods by populations of lower socioeconomic status (SES).[9,16] The combined effects of these processes can propel the nutrition transition.

Further exacerbating the effects of nutrition transition is access to technological advances that reduce physical activity, both at work and at home. This is otherwise known as the technologic transition.[17] Widespread access to television and other electronic-based entertainment systems at home and mechanized labor systems at work, as well as changes in motorized transportation methods (particularly higher rates of car ownership), have reduced daily energy expenditure.[14,18–20] When the effects of nutrition transition are coupled with the technological transition, this promotes an increasingly sedentary lifestyle with decreased physical activity, fostering an obesogenic environment, ultimately giving rise to increased rates of obesity and other diet-related chronic illnesses.

These factors explain the increasing rates of obesity in nutrition transitioning LMICs, however in the persistence of underweight and child stunting in LMICs illustrates the paradox of the dual burden of malnutrition—the bimodal distribution of both underweight and stunting along with overweight and obesity in the same population. Historically, undernutrition has been linked to higher prevalence of communicable diseases; as countries experience socioeconomic

and epidemiologic transition, an increase in diet-related, non-communicable diseases replaces the burden of infectious disease. However, due to global advances in healthcare and sanitation, the burden of malnutrition in LMICs no longer conforms to the old model of transition, especially as these advances have not reached many countries, or may not be equally distributed across a single country's regions. Instead, a modified pattern referred to as the *protracted-polarized model* better describes modern epidemiologic transition, in which infectious disease and NCDs coexist over long periods of time.[21] Application of this phenomena to the nutrition transition and the dual burden of malnutrition has been documented worldwide in diverse countries such as Brazil, China, Colombia, Egypt, Guatemala, India, Malaysia, Mexico, Philippines, South Africa, and Vietnam.[1,10,22–31] This body of research indicates that the dual burden of malnutrition is most commonly borne by low-SES populations in countries experiencing rapid globalization and urbanization.[10,27–29]

The dual burden of malnutrition is not well documented in Haiti, though the country shows early signs of nutrition transition.[32] One study focused at the household level examined the anthropometric profile and socioeconomic characteristics in a shantytown in Haiti. It found that 14% of the 203 houses surveyed met the criteria for a dual burden household.[33] Beyond this study, no other work has been recently published to the awareness of the author. However, in 2014, 38.5% of the Haitian adult population was overweight or obese.[34] One recent study examining the determinants of childhood/adolescent overweight/obesity in Haiti found that, of 968 school-age children and adolescents in six primary schools in Cap-Haïtien, 5.1% were overweight or obese.[32] This indicates that it is necessary to determine and describe the prevalence of the dual burden of malnutrition in Haiti, not just at the household level, but also at the population level for school-age children and adolescents.

As Haiti's public health nutrition programs face the new complexities of nutrition transition and the dual burden of malnutrition, there is an opportunity to draw on experiences and evidence from previously transitioning countries so as to intervene early and appropriately. Previous work indicates the necessity for considering the development of the dual burden of malnutrition within low-income, urban Haitian populations in order to guide the planning and implementation of nutrition- and physical activity-based interventions for either end of the malnutrition spectrum.[10,32,35] Interventions aimed at school-going adolescents represent an opportunity for early prevention of the public health consequences of the dual burden of malnutrition. Furthermore, abundant nutrition-focused literature is available for Haiti, representing only one factor of the paradigm for achieving and maintaining a healthy body composition within the context of the dual burden; research on the physical activity patterns of Haitians is extremely lacking. This dissertation is a first step in characterizing the link between the emergence of the dual burden of malnutrition and its risk factors. It ultimately provides rationale for early adoption of policy and program development for school-based physical activity and nutrition assistance programs in Haiti, thus improving the prevention and control of the continuing malnutrition problems of the country.

1.1.1 Current Indicators

L'Enquête Mortalité, Morbidité et Utilisation des Services (EMMUS; translated as The Mortality, Morbidity and Utilization Survey) is a Demographic and Health Survey (DHS), which is a nationally-representative, cross-sectional household survey conducted by the United States Agency for International Development (USAID) approximately every five years, which provides data for monitoring and impact evaluation, including population/demographic, health, and nutrition indicators. Three recent EMMUS DHS studies provide health data for Haiti during the

years of 2005-2006, 2012, and 2016-2017.[36–38] Data from the EMMUS DHS will be used for reporting the indicators for the nutrition transition and dual burden of malnutrition throughout this chapter.

1.2 Defining the Dual Burden of Malnutrition

The dual burden of malnutrition is a relatively new concept for study in LMICs undergoing nutrition transition.[9] The dual burden of malnutrition may be attributable to socioecological changes resulting from globalization, urbanization, demographic transition, epidemiologic transition, and technologic transition. As all transitions exist on a continuum, though global improvements in healthcare, sanitation, and the availability of nutrition assistance programs have brought about reductions in acute and chronic undernutrition rates, evidence of micronutrient deficiencies, wasting, and stunting persists in many LMICs alongside increasing rates of obesity and diet-related non-communicable chronic diseases (DR-NCDs). Countries in the earlier stages of nutrition transition see a larger coexistence of persistent undernutrition and increasing rates of obesity. For example, women living in rural areas in Benin, India, and Haiti—three countries in the earliest stages of nutrition transition—experience higher rates of undernutrition than obesity.[39] However, all three of these countries have seen increases in overweight and obesity prevalence.[37,40,41]

The dual burden of malnutrition has been predominantly operationalized as a measure of the presence of underweight and overweight members of the same household—most commonly as an overweight/obese mother and underweight or stunted child. Fewer studies have focused at the population level, characterizing the bimodal distribution of underweight/stunting and overweight/obesity within an age-specific population. Many studies on the dual burden have been set in Latin America, examining modifiable risk factors at the national, household/family,

and individual level. A country's Gross National Product (GNP) has been identified as a significant determinant of the dual burden of malnutrition in Latin America, as it influences many of the variables previously discussed in regards to nutrition transition.[10,29] For example, GNP is related to globalization, rates of urbanization, maternal education, health care access, and adequate sanitation, which are all variables linked to both childhood/adolescent underweight and obesity.[42] In order to characterize the various dimensions of the problem of the dual burden of malnutrition in Haiti and elsewhere, key concepts and definitions are presented below.

1.2.1 Undernutrition

Undernutrition is a leading cause of death for children under 5 years of age, including death attributable to micronutrient deficiencies, underweight, diarrheal diseases from lack of safe water and sanitation, and suboptimal breastfeeding practices.[43] Undernutrition and suboptimum breast feeding practices are responsible for elevated risk of infectious disease and death, significantly impacting disability-adjusted life-years (DALYs) in children under 5 years of age.[44] In order to address and reverse the harmful impacts of childhood undernutrition, Millennium Development Goal (MDG) No. 1 was designated to "eradicate extreme poverty and hunger," specifically aiming to decrease the prevalence of underweight children under five years of age by 50% between 1990 and 2015.[45] For this reason, the literature has largely focused on up to 5 years of age if examining effects beyond the first 1,000 days, and there is little documentation focused directly on school-age children, specifically adolescents. However, special attention to the nutrition of adolescents is necessary, as it represents a highly vulnerable period for nutrition and development—a discussion which will be elaborated upon later in Section IV of this chapter.

Though significant progress has been achieved in reducing overall global undernutrition, one study cited lack of progress in Africa and Asia as a reason the MDG will not be met.[46]

Indeed, the WHO reports that 150 million children are still underweight and 200 million children are still stunted, and the majority of them are located in the regions of Africa, Asia, and Latin America.[47] In Haiti, overall progress in reducing undernutrition has been mitigated by the persistent rates of stunting in children under 5 years of age; only a 1.8% reduction in stunting was seen between 2005-2006 and 2012, and 0% reduction between 2012 and 2017.[36–38]

Classification

Overall Undernutrition. The term undernutrition encompasses conditions of micronutrient deficiency, underweight, wasting, and stunting. Underweight is defined as low weight-for-age, where weight is referenced against international standards for age and sex.[48] WHO guidelines operationalize underweight as a weight-for-age Z-score 2 standard deviations below the median distribution of the population. In 2005, the prevalence of underweight in LMICs was reported at 20% for children under 5 years of age.[44] During that same time, Haiti reported 22.2% of children under the age of 5 were underweight.[36] The prevalence of underweight is steadily declining, as the 2012 EMMUS DHS reported prevalence to be 11.4%, and the 2017 report showed further reduction to 9.5%.[37,38] Short-term undernutrition and micronutrient deficiency are linked to acute wasting, whereas prolonged undernutrition is linked to stunting, a chronic condition. Overall prevalence in undernutrition is more sensitive to reductions in wasting than stunting, as the manifestation of acute underweight is more readily reversible than the lasting effects of stunting.[44,49]

Wasting. Acute undernutrition is termed "wasting." Fifty-five million children (10%) in LMICs suffered from wasting in 2005, with the burden concentrated in Asia and Africa.[44] Haiti reported 9.1% of children were wasting during that same time.[36] The prevalence had decreased to 5.1% as of 2012, and further diminished to 3.7% as of 2017.[37,38] The effects of wasting are short-

term, if addressed in a timely manner.[50] As an indicator of undernutrition, wasting is highly sensitive to health and nutritional status, including recent and current episodes of food deprivation, pneumonia, diarrhea, worms, and other indicators of food security and sanitation.[2] As such, improvements to sanitation and feeding programs can significantly contribute to reductions in wasting. Wasting is operationalized in children under 5 years of age as a weight-for-height Z-score less than 2 standard deviations of the median for the reference population.[48] Understanding this calculation is important for the targeted implementation of feeding programs and interventions addressing the dual burden of obesity, primarily because an underweight child or adolescent that is also stunted could be classified as a normal weight child/adolescent based on weight-for-height measurements. Thus it is necessary to use measures for both wasting and stunting in order to properly classify the weight status of children.[50,51]

Stunting. Chronic undernutrition is termed "stunting." Stunting is slowed linear and skeletal growth and subsequent short stature resulting from nutrition deficiencies. In 2011, 160 million children (28%) under five years of age in LMICs were chronically malnourished.[49] The 2012 EMMUS DHS reported that 21.9% of Haitian children were stunted, a decrease from 23.8% from the 2007 report.[36,37] As of the 2017, report, stunting prevalence remained unchanged at 21.9%.[38] Stunting is the result of cumulative (chronic) nutrient deprivation, and thus this indicator is less sensitive to acute episodes of food insecurity or infectious disease. Furthermore, this indicator of overall undernutrition demonstrates slower rates of improvement as it is rooted in long-term causes (*e.g.*, poverty).[52] The effects of stunting are long-term if not treated before the child is 2-3 years of age.[52] However, new research has identified the adolescent growth spurt as a period of catch-up growth, which will be further discussed later in

this chapter.[53] Stunting is operationalized as a height-for-age Z-score less than 2 standard deviations of the median for the reference population.[48]

Health Consequences of Undernutrition

Childhood and adolescent undernutrition have both short- and long-term health consequences, increasing susceptibility to infectious (linked to short-term undernutrition) and chronic (linked to long-term undernutrition) diseases. The following section elaborates upon different health consequences associated with both.

Low birth weight (LBW), intrauterine growth restriction (IUGR), and Subjective Global Assessment (SGA) are all used as proxy measures for fetal undernutrition.[44,54,55] Subjective Global Assessment uses a clinical examination and self-report history of nutrition status that classifies patients as well nourished, moderately malnourish, or severely malnourished.[55] As a measure of fetal growth, SGA is used to compare the infant's weight to the distribution of birth weight of all infants in the same week of gestation.[54] Intrauterine growth restriction is applied to births where the infant has a lower weight than would have been attained had the pregnancy been designated "normal," though this can prove problematic as it is difficult to define a relative "normal" pregnancy, as the possible expected outcome cannot be defined.[54] As such, different studies using IUGR as a measure of fetal undernutrition may not be comparable.

Low birth weight is the most common proxy for fetal undernutrition.[54] A link between LBW and fetal undernutrition has been established in the literature.[44] Fetal undernutrition has been linked to increased risk of neonatal death due to asphyxia and infections like sepsis, pneumonia, and diarrhea.[44] Also, frequent infection can exacerbate the effects of inadequate diet, amplifying micronutrient deficiencies and undernutrition.[43] The effects are cyclical, as underweight children and adolescents more frequently suffer from severe infections and

experience increased risk of death; approximately 60% of childhood/adolescent diarrhea, measles, malaria, and lower respiratory infection are attributable to underweight.[43]

Low birth weight has also been linked to adult NCDs (*e.g.*, metabolic disorder and cardiovascular disease) as a result of metabolic, anatomical, and endocrine alterations in the nutrient-deprived fetus.[44,49,56–58] The relationship between LBW, these physiological alterations, and DR-NCDs is mediated by *catch-up growth* during childhood and adolescence—a phenomena that will be further elucidate in Section 1.4.4.[59,60] However, *in utero* changes in the body's response to insulin (*i.e.*, the thrifty phenotype) may become disadvantageous later in life when the need for excess fat storage is no longer necessary for survival.[61] As a result, catch-up growth has been shown to favor the deposition of fat over lean tissue.[62] As such, when a child with the thrifty phenotype experiences an environment undergoing rapid nutrition transition, the metabolic abnormalities are no longer beneficial for survival and instead manifest as negative health outcomes like abdominal fat accumulation, chronic low-grade inflammation, and DR-NCDs.[63] This hypothesis is supported by research showing LBW children remaining in nutrient-poor environments into adulthood do not experience higher risk of DR-NCDs, while thinness in childhood followed by overweight in adolescence and adulthood increases the risk of NCDs later in life.[56,64] This hypothesis is known as the *thrifty phenotype hypothesis*, which will be discussed in Section 1.4.3.

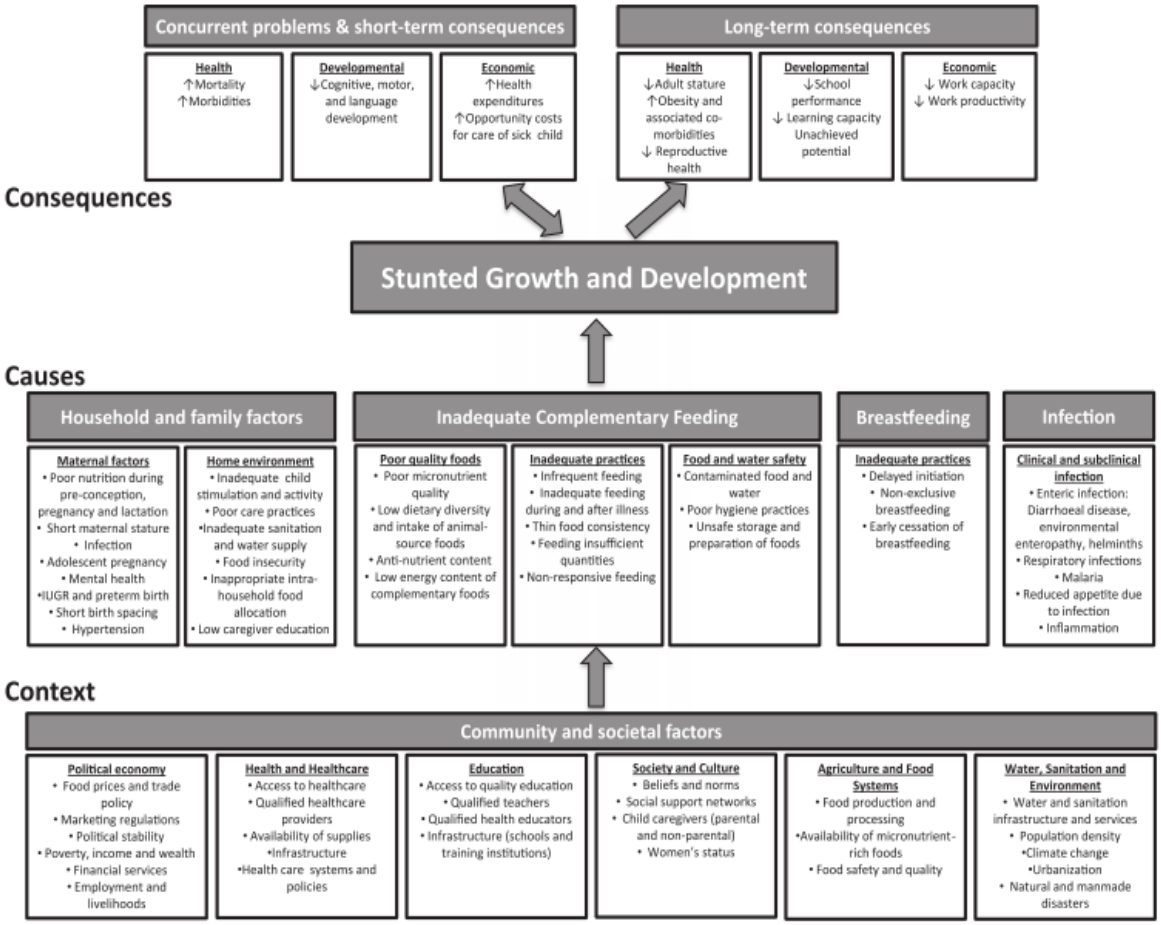

Figure 1.1 *WHO conceptual framework on childhood stunting: Context, causes, consequences, with an emphasis on complimentary feeding* (taken from Stewart et al., 2013).

A social-ecological framework developed by Stewart and colleagues details the context, causes, and consequences of stunted growth and development related to undernutrition (Figure 1.1).[65] Within the context of low SES, reduced access to health care, poor education, and inadequate environmental hygiene and sanitation; poor maternal nutrition before, during, and after pregnancy as well as poor nutrition during the first 3-5 years of life result in negative short- and long-term social and health consequences for the child. Chronic childhood undernutrition has been linked to short-term effects like increased morbidity and mortality, related increased

health expenditures, and decreased cognitive and motor development.[65] Long-term effects include stunting, poor pregnancy outcomes, and decreased ability to work.[43] Stunting has been linked to preferential abdominal fat storage and other metabolic risk factors that increase the risk for adulthood obesity and its comorbidities.[58,62,65–67] Concomitant childhood/adolescent stunting and childhood/adolescent abdominal obesity have been documented in LMICs.[68] As such, LMICs undergoing rapid nutrition transition are at risk for new public health concerns when increasingly obesogenic environments are developing around populations of children and adolescents with impaired metabolic capacities.[69]

1.2.2 Overweight & Obesity

Rates of overweight and obesity are rapidly increasing in all global regions and across all age groups; global rates of obesity have increased by more than 100% since 1980.[47,70,71] Forty-one million children under the age of 5 were overweight or obese and over 340 million children and adolescents aged 5-19 were overweight or obese in 2016.[70] Most of these cases are attributable to continued energy imbalance (greater energy intake than expenditure), mediated by environmental characteristics like changing food environments paired with decreasing physical activity and increasing sedentary time, which will be discussed in greater detail in Section III of this chapter. Overweight and obesity are linked to increased morbidity and mortality and are considered NCDs themselves, but have also been linked to increased risk of other NCDs like diabetes, metabolic syndrome (hypertension and dyslipidemia), coronary heart disease, atherosclerosis, stroke, non-alcoholic fatty liver disease, osteoarthritis, and certain cancers.[72] Obese adolescents experience the same comorbid NCD risks as obese adults, including hypertension, chronic inflammation, type II diabetes, and other cardiovascular disease risk factors.[73] Additionally, adolescent obesity may have psychosocial consequences on self-esteem,

body image, and economic mobility that can carry into adulthood.[74] Adult obesity is linked to diabetes, cardiovascular disease, musculoskeletal disorders, and some cancers.[70]

Rates of obesity are growing in Haiti; in 2005-2006, over 21% of women 15-49 years of age were either overweight or obese, but by 2012, over 25% were overweight or obese.[36,37] In 2012, 8% of children were overweight or obese.[37] According to a 2014 study, Haiti's national prevalence of overweight and obesity in children during 1980–2013 for boys and girls was 7.7% overweight and obese (2.1% obese) and 9.5% overweight and obese (2.0% obese), respectively.[75] The 2005-2006 EMMUS DHS did not report overweight and obesity for children, as the emergence of this public health problem was not yet of great significance in the country.[36] However, by the 2012 EMMUS DHS, the rate of overweight and obesity for children under the age of 5 years was found to be 3.6%; and overweight and obesity for all children under the age of 18 (excluding those 6 months and younger) was found to be 8%.[37] The 2017 report did not provide overweight and obesity statistics for children 6 months- 18 years, but did report a prevalence of 3.4% for children 5 years and under.[38] Neither report classified the difference between overweight and obesity, another indication of the country's early position on the nutrition transition continuum and the recent emergence of this health concern.

Classification

Weight and height measures are used to classify overweight and obesity. Body mass index (BMI) is an index of weight-for-height.[71] It is an anthropometric measure based on Quetelet's index, calculated by dividing a person's weight in kilograms by their height in square meters (kg/m^2).[76,77] In children and adolescents, a z-score is calculated for BMI, which expresses the weight-for-height anthropometric value as the number of standard deviations from the mean. The WHO provides a formula and software (Anthro and AnthroPlus) for calculating BMI z-score

(BAZs).[78–80] The standard deviation classification system offers advantages in that summary statistics can be applied to groups of BAZs. Furthermore, the z-score scale is linear and sex-independent for all subjects in the same age group, providing a fixed interval for evaluating differences in growth status amongst groups of different ages and sexes.[79]

BMI has been highly correlated with body fat percentage using densitometry and skin-fold thickness.[77] BMI, however, only serves as an indirect measure of overweight and obesity as it does not distinguish between weight from adiposity, weight from muscular tissue, or weight from edema.[81] Thus, other measures are necessary, such as measures of fat-mass and fat-free mass (including total body water and bone mineral mass) in capturing the of an individual's body composition, which will be discussed in greater detail in Section V of this chapter.[82] It is important to distinguish between overweight and obesity in this work and in the literature for several reasons. Graded classification of body weight provides for: meaningful comparisons of weight status both within and between populations; identification of individuals and groups with increased risk of morbidity and mortality; identification of priorities for intervention; and a solid foundation for evaluating interventions.[71]

Overweight. Overweight is defined differently for children/adolescents and adults. In school-age children and adolescents (age 10-19 years), overweight is defined as high BMI for age and sex, operationalized as a BAZ *one* standard deviation above the median distribution of the population.[72] For children under 5 years of age, overweight is defined as a BAZ two standard deviations above the median distribution of the populations.[72] In adults, overweight is defined as a BMI $\geq$25.00 kg/m^2.[70] Overweight poses significant health threats, including increased morbidity and elevated risk of cardiovascular disease, though the risk of poor health outcomes is less severe for overweight than it is for obesity.[83] Overweight can be clinically viewed as *pre-*

obesity; individuals with BMIs 27.50 kg/m² - 29.99 kg/m^2 are at increased risk of obesity and its associated comorbidities.[83]

In the 2005-2006 Haiti EMMUS DHS survey, 14.9% of women of childbearing age (15-49 years) were overweight.[36] The proportion of women with a BMI ≥25.00 kg/m² increases with age: 6.9% for 15-19 years, 17.4% for 20-29 years, 18.8% for 30-39 years, and 17.3% in 40-49 years. Overweight was more common among women in urbanized settings (18.8% urban vs. 11.3% rural), with the most education (26.8%), and with higher incomes (34.9%). By the 2012 EMMUS DHS survey, these numbers had increased for the same demographic: 17.4% of women were overweight and the proportion followed the same age-associated pattern as the previous survey (5.7% 15-19 years, 17.1% 20-29 years, 25.3% 30-39 years, 24.3% 40-49 years).[37] Overweight was highest in women living in urban areas (20.5% urban vs. 14.7% rural), with the highest education (19.4%), and with the highest income (23.1%).[37]

Obesity. Obesity is also defined differently for children/adolescents and adults. In school-age children and adolescents (age 10-19 years), obesity is defined the same way as overweight, but operationalized as BAZ *two* standard deviations above the median distribution of the population.[72] In adults, obesity is defined as a BMI ≥30.00 kg/m².[70] The WHO has provided further sub-classifications of obesity to elucidate the different health risks associated with excessive body weight: class I obesity is associated with BMIs 30.00 kg/m² - 34.99 kg/m²; class II obesity is associated with BMIs 35.00 kg/m² - 39.99 kg/m²; and class III obesity is associated with BMIs ≥40.00 kg/m².[71] The WHO has commissioned research and panel discussions to ascertain the relevance of developing population-specific cutoffs for various ethnicities, as median stature and the consequences of excess body weight may manifest differently across groups with different genetic ancestry.[84,85] For example, lower BMI cut-points for classification

of obesity may be more appropriate for some Asian populations as a specific BMI reflects a higher percentage of body fat in these groups than in white or European populations.[84,85] This is of relevance to the future study of obesity in Haiti, as the population is traditionally of smaller stature, due to the historical prevalence of underweight and stunting. As such, a lower BMI may indicate a different percentage of body fat and body fat distribution in the country. The WHO recommends maintaining the use of current cut-off points for all global populations until further research can be conducted.[84] Monitoring the results of this research and any modifications to the BMI cut-off points will be necessary to maintain the validity and relevance of future obesity research in Haiti.

The results of the 2005-2006 EMMUS DHS survey reported 6.3% of women of child-bearing age were obese, with the proportion increasing with age (0.08% 15-19 years, 4.3% 20-29 years, 12.5% 30-39 years, 10.5% 40-49 years).[36] Rates of obesity were higher in in women living urban (9.0%) than rural (3.6%), and highest amongst women with the highest education (8.7%) and highest income (13.0%). By the 2012 EMMUS DHS survey, these numbers had increased for the same demographic: 7.8% of women were obese and the proportion followed the same age-associated pattern as the previous survey (0.5% 15-19 years, 5.9% 20-29 years, 13.4% 30-39 years, 14.6% 40-49 years).[37] Again, obesity was highest in women living in urban areas (10.7% urban vs. 5.1% rural), with the highest education (9.4%), and with the highest income (15.3%).[37]

1.3 Defining the Nutrition Transition

The nutrition transition is defined both as a) a shift from high prevalence of undernutrition and its related health consequences to increasing predominance of DR-NCDs, and b) the broad patterns of diet, activity, and body composition that are found as a result of the various stages of this transition.[23,86] The processes of globalization, urbanization, economic

growth, and technological advances fuel nutrition transition, culminating in decreased levels of physical activity and changes in patterns of food choice and nutrient intake. Nutrition transition influences and is influenced by other well-documented transitions in LMICs, including demographic, epidemiologic, technologic, and socioeconomic transitions, which will be discussed in the following section. Popkin describes five broad stages of nutrition transition, as summarized in Table 1.1.[7] The nutrition transition is characterized both by these distinctive stages and as a continuum of transition; a country's progress from one stage of transition to the next is not rigid, but fluid, as it is dependent upon many multifaceted variables of social context, economy, and demography. Most Latin American and Caribbean countries are transitioning between stages three (receding famine) and four (degenerative diseases).[86] Literature describing the nutritional intake and demographics of Haiti indicate that the country is also transitioning between stages three and four. However, there is evidence to support that Haiti is still earlier on the transition spectrum; childhood underweight and wasting have declined, but stunting and anemia persist even as obesity and other DR-NCD rates increase.[32,37,87,88]

1.3.1 Globalization and Urbanization

Haiti, amongst many other LMICs, is experiencing significant transitions as a result of globalization and urbanization. Globalization is defined here as the process of interaction and integration of a country into the worldwide market and culture, as driven by international trade and supported by information technology.[16,89] It is a marked characteristic of economic growth in LMICs. Accompanying this economic growth is the rapid process of urbanization, evidenced by an increase in the proportion of the population living in urban centers. Globalization of food markets has made mass-produced, low-cost, high-energy-density foods more widely available in LMICs, contributing to changes in dietary patterns that increase

Table 1.1. *Summary of the broad stages of nutrition transition and their relationship to demographic and epidemiologic transition*

Social & Economic Factors	Stage 1: Collecting Food	Stage 2: Famine	Stage 3: Receding Famine	Stage 4: Degenerative Disease	Stage 5: Behavioral Change
Nutrition					
Diet	Plants, wild animals; varied diet	Cereals predominant; diet less varied	Fewer starchy staples; more fruits, vegetables, animal protein; low-variety continues	More fat (especially from animal products), sugar, and processed foods; less fiber	Less fat and processing; increased carbohydrates, fruits, and vegetables.
Food Processing	Rudimentary	Food storage begins	Storage process (drying, salting); canning and processing technologies; increased food refining and milling	Numerous food-transforming technologies	Technologies create foods and food constituent substitutes (*e.g.*, macronutrient substitutes)
Nutrition Status	Robust, lean, few nutritional deficiencies	Children, women suffer most from low fat intake; nutritional deficiency diseases emerge; stature declines	Continued maternal/child nutrition problems; many deficiencies disappear; weaning diseases emerge; stature grows	Obesity; problems for elderly; many disabling conditions	Reduced body fat levels and obesity; improved bone health
Demography and Epidemiology					
Mortality/ Fertility	Low fertility, high-mortality; low life expectancy	High natural fertility, low life expectancy, high infant and maternal mortality	Mortality decline; fertility static then declines; cumulative population growth	Life expectancy reaches high levels (60s-70s); fertility low and fluctuating	Life expectancy tends to 70s, 80s; disability-free life expectancy increases
Morbidity	Much infectious disease; no epidemics	Epidemics; endemic diseases (plague, smallpox, polio, TB); deficiency begins; starvation common	TB, smallpox, infection, parasitic disease, polio, weaning disease (diarrhea, retarded growth) expand, then decline	Chronic disease related to diet, pollution (heart disease, cancer); infectious disease declines	Increased health promotion (preventive and therapeutic); decline in coronary heart disease, improvement in age-specific-cancer profile
Age Structure	Young population	Young; very few elderly	Chiefly young; shift to older population begins	Fertility decline; elderly proportion increases	Increasing proportion of elderly >75 years
Residency Patterns	Low density	Rural; a few small, crowded cities	Chiefly rural; move to cities increases; international migration begins; large cities develop	Urban population disperses; rural green space reduced	Lower-density cities rejuvenate; urbanization of rural areas around cities increases

Note. Adapted from Popkin, B. M. (1993). Nutritional Patterns and Transitions. *Population and Development Review*, *19*(1), 138–157. http://doi.org/10.2307/2938388

caloric consumption, but do not necessarily increase micronutrient consumption.[7,9,14] There is a universal shift in diet composition, characterized by increased consumption of sweeteners, animal source foods, and edible oils.[86] Furthermore, processed foods replace unprocessed ones, representing a large shift toward refined carbohydrates.[86] The effects of globalization are major drivers of large changes in population diet composition, which is the nutrition transition.

Definitions

Globalization. Globalization of LMICs leads to increases in production of high-processed foods (*e.g.*, refined carbohydrates), replacement of healthier preparation techniques (*e.g.*, boiling, steaming) with less healthy methods (*e.g.*, frying, grilling), and away-from-home meal consumption, all propelling nutrition transition.[86] Free-trade markets are profit driven, and as LMICs enter into the global market, mass-produced, low-cost, high-energy dense foods and sugar-sweetened beverages (SSBs) available in supermarkets and multinational fast-food restaurants are quickly replacing fresh foods available in traditional open-air market settings.[16,90] Additionally, globalization's influence on food marketing, prices, and availability largely influences changes in nutrition preferences and the food environment, which will be discussed in greater detail later in this chapter. As more and more multinational food corporations enter the country, widespread availability of processed foods and accompanying advertising campaigns leads to increased consumption of energy-dense, nutrient-poor foods. The most notable examples include the McDonald's and Coca-Cola Company's global presence, even in the most rural regions of the world.[91,92] The Coca-Cola Company has a large presence in Haiti, including the Haiti Hope Project, which aims to build a sustainable mango juice industry in order to bolster the nation's economy.[93] However, there are no McDonald's franchises present in the country, one indicator that Haiti is still in the early stages of transition.[92]

Urbanization. One of the most prominent effects of globalization on nutrition transition manifests via the rapid urbanization that accompanies economic growth and entrance into the worldwide market. In the developed world, urbanization is a common and well-understood process. Perhaps less well known is that Latin American and Caribbean nations are already highly urbanized as well, with 75% of their populations residing in urban areas. In Haiti, 56% of the total population resided in urban areas as of 2013.[94] As cities in Haiti continue to grow, the country will face new public health concerns associated with urbanization, increasing risk factors for both communicable and non-communicable diseases alike. Correlates of urbanization include psychological and social problems, sedentary lifestyle, poor sanitation, air and water pollution, and dietary changes.[13,90,95–99]

Urbanization's linkage to greater access to modern mass media, transportation systems, and large supermarkets has particularly significant consequences for the nutrition transition.[100,101] As individuals are transplanted into urbanized settings, the threat of food scarcity is diminished, but the protective effects of family connectedness and subsistence agriculture are also diminished, contributing to increased consumption of poor-quality and energy-dense, but cheap and affordable foods.[9,16] Additionally, increased exposure to food marketing and increased accessibility of fast food chains are linked to urbanization.[100]

A scale of "urbanicity" was developed in order to evaluate the impact of urbanization on nutrition transition, including such measures as access to markets, transportation, health, education, and housing.[16] It showed that the high scores of urbanicity and urban sprawl were associated with decreased physical activity and increased sedentary time as reliance on transportation systems increased, and were also linked to increased consumption of fats and animal source foods.[16] This indicates that, at current urbanization rates of +3.68%, Haiti can

expect a rise in public health concerns related to poor diet and low physical activity.[102] Indeed, as globalization and urbanization continue, novel interventions will be required in order to combat emerging DR-NCDs within the nation, while still addressing any lingering health problems related to undernutrition.

1.3.2 Interplay with Other Transitions

Globalization has also influenced other transitional phenomena as it has introduced economic growth as well as advances in healthcare, sanitation, and technology to LMICs. These advances, in turn, have led to epidemiologic transition (a shift from high infectious disease morbidity and mortality to the dominance of NCDs), a so-called technologic transition (defined here as increased widespread access to technological advances incorporated into daily life that reduce physical activity, both at work and at home), demographic transition (a shift from high to low fertility and mortality and increased population aging), and the physical activity transition (a shift from traditionally active lifestyles to modernized, more sedentary lifestyles).[9,17,86,103–107] Such transitions in the demographic, epidemiologic, technologic, economic, and physical activity trends in Haiti are driving major changes in population health.

Epidemiologic Transition. The first characterization of epidemiologic transition was in the early 1970s.[106] Concomitant improvements in living conditions, sanitation, and healthcare alongside integration into global markets have seen decreased communicable disease rates paired with increased DR-NCD rates. Most LMICs experienced the beginning stages of epidemiologic transition in the 20th century, when the development of antibiotics and other advances in healthcare lead to dramatic decreases in infectious disease rates, and ultimately reduced rates of crude mortality.[108] Traditionally, undernutrition and its related sequelae have been linked to the earlier stages of epidemiologic transition, while overweight/obesity and DR-NCD rates have

been associated with latter stages of the epidemiologic transition continuum.[26] However, despite advances in sanitation and feeding programs aimed at reducing diarrheal disease and undernutrition, micronutrient deficiencies and stunting still persist in LMICs. Thus, the burden of malnutrition no longer strictly conforms to the old model of epidemiologic transition; instead a polarized-protracted model has been adopted, showing the overlap of infectious disease and undernutrition with DR-NCDS and overweight/obesity in countries that are earlier on the transition continuum, including a description of double burden of mortality.[26] Consequently, an apparent paradox arises in the implementation of feeding programs in LMICs, as the goals of eradicating undernutrition and obesity prevention exist in inherent conflict.[35] Indeed, universal application of supplementary feeding programs has been linked to both decreasing rates of underweight and wasting as well as the increasing trends of obesity.[35,109] This substantiates the need for targeted implementation of feeding programs, tailored to the needs of sub-populations within LMICs.

Evidence of the epidemiologic transition in Haiti can be seen in several key indicators. Vaccination rates in children have steadily increased over the last two decades, from 30% of children age 12-23 months receiving all the recommended vaccinations to 45%.[37] Similar, but less dramatic trends are also apparent in diarrhea rates in children, down to 20.8% in 2012 from 23.7% in 2005-2006.[36,37] Estimates from 2012 categorize almost 5.1% of children as underweight in Haiti, ranking 33rd globally—a marked improvement from 9.1% in 2005-2006.[36,37] However, progress in reducing stunting has been less striking; 22% of children were stunted in 2012, only down by 1.8% from 2005-2006.[36,37] Little data is currently available on overweight and obesity rates for young children in the country. In 2012, the first national reports to include any measure of overweight or obesity in children found 8% of school-age children

under 18 years and 4% of children under 5 years were classified as overweight or obese.[37] A more recent study showed that just over 5% of the 968 school-age children (ages 3-13) were overweight or obese.[32] The need to further evaluate the prevalence of overweight/obesity in Haiti is necessary to fully understand the potential influence of the dual burden of malnutrition on the country's progress along the epidemiologic transition. Indeed, as underweight/stunting and overweight/obesity have strong links to NCD later in life, the effects of the dual burden of malnutrition will be interconnected with epidemiologic transition.

Demographic Transition. Demographic transition is a global phenomenon. Most LMICs experienced the beginning stages of demographic transition during the 20th century, when technological advances and improved quality and coverage of health care resulted in a rapid fall in crude death rates globally.[108] Demographic transition affects and is affected by epidemiologic transition; progress along one continuum is mirrored in the other. After the first stages of epidemiologic transition prompt declines in infectious disease, the early stages of demographic transition show reductions in mortality rates. As populations do not immediately adjust fertility levels to match the reduced risk of death, countries experience population growth during the middle stages of demographic transition. Later in the demographic transition continuum, fertility drops and the average age of the population increases, mirroring the increased rates of NCDs seen in the later stages of epidemiologic transition.[7,108,109] As previously stated, both expressions of malnutrition have strong links to NCD later in life, meaning that concurrent demographic and nutrition transitions can further exacerbate the effects of the dual burden of malnutrition, placing undue burden on the health of the population and the health systems meant to treat them. This calls for public health prevention efforts against the dual burden of malnutrition and increasing prevalence of NCDs.

There is evidence of the demographic transition in Haiti. Infant and childhood mortality as well as fertility have steadily declined in the last two decades; infant mortality has decreased from 79 deaths for 1,000 live births to 59 deaths for 1,000 live births, childhood mortality has decreased from 112 deaths for 1,000 live births, and women in Haiti have, on average, 3.5 children, down from 4.8 children 20 years ago.[37] Haiti has also experienced an increase in life expectancy. In 2012, life expectancy was 60.7 years for men and 64.3 years for women, up from 57 years for men and 59 years for women in 2005-2006.[36,37] As the country's average age and life expectancy continue to grow, it will be important to focus interventions at preventing the dual burden of malnutrition in order to mitigate the future economic and social effects of a sick, aging population.

Technologic Transition. Technological innovations have been documented throughout human history, with the most rapid advances occurring in the last two centuries. Technologic transition has been documented in historical science, evolutionary economics, technology studies, anthropology, the nutrition transition, and many other fields.[7,17] It is the study of how technological innovation occurs and is incorporated into culture and society.[105] Within the context of nutrition transition, it is related to the advances in cooking and food preparation technology, which drives changes in dietary patterns.[103] For example, advances in technology increase the production of high-processed foods with high caloric content but low nutritive value (*e.g.*, sweeteners, refined carbohydrates) and replacement of healthier preparation techniques (*e.g.*, boiling, steaming) with less healthy methods (*e.g.*, frying, grilling).[86] Furthermore, technologic transition has been linked to reduced physical activity levels and increased sedentary time, as increased access to and use of technology both at work and at home has automated many daily activities that used to require greater energy expenditure.[9,86] Specifically, television

viewing and automotive transport have been cited as major drivers of overweight and obesity in adults, children, and adolescents.[86,104] The energy imbalance (*i.e.*, increased calorie intake combined with decreased calorie output) resulting from technologic transition is a driver of obesity, with strong similarities to transition along the nutrition transition continuum. Thus, understanding a country's current use of technology and potential for future adoption of new advancements will have profound effect on the design and implementation of interventions for the dual burden of malnutrition.

Table 1.2. *Percent of Haitian households owning technological goods between 2005-2006 and 2012*

Technology	2005-2006			2012		
	Urban	Rural	Total	Urban	Rural	Total
Radio	77.6%	50.1%	60.7%	69.3%	46.4%	54.8%
Television	52.2%	8.2%	25.3%	58.0%	11.2%	29.4%
Mobile Phone	35.0%	6.1%	17.3%	91.8%	67.5%	77.2%
Landline	9.2%	1.3%	4.4%	3.5%	0.7%	1.8%
Refrigerator	21.4%	2.3%	9.7%	22.0%	2.7%	9.9%

Note. Adapted from Cayemittes,, et al. (2007). *Enquete Mortalite, Morbidite et Utilisation des Services (EMMUS IV)* and Cayemittes, et al. (2013). *Enquête Mortalité, Morbidité et Utilisation des Services (EMMUS V).*

Haiti has seen slow technological advancement in the last decade. From 2005 to 2012, minor, but marked increases in household ownership of technological goods were seen, as summarized in Table 1.2.[36,37] This small advancement is likely attributable to widespread poverty within the country, further evidenced by the lack of reporting on any kind in 2017.[38] Computer ownership and internet access were so rare in 2005-2006, that rates were not reported.[36] However, by 2012, 4.4% of households had a computer and 2.5% of households had an internet connection; the proportion was higher in urban areas (9.6% computer, 5.2% internet connection) than rural areas (1.3% computer, 0.9% internet connection).[37] In addition, 8.5% of households have a stove for food preparation. In regards to transportation, 7.8% a motorcycle or scooter and 4.6% of households have a car or truck, up from 2.6% and 4.7% in 2005-2006.[36,37] However, the percentage of households owning a bicycle has decreased by roughly half since

2005-2006 (17.5% in 2005-2006 and 8.6% in 2012). While data on related physical activity levels and sedentary time in Haitian populations are not available, these trends in technological advancement imply the need for study of the relationship between technology availability, energy expenditure, and the nutrition transition in the Haiti.

The most dramatic increase in ownership of technological goods was seen in mobile phone ownership, which increased by nearly 60% from 2005-2006 to 2012.[36,37] This represents an interesting point of future study, as this has implications for health-related communications within the country. Phone-based interventions for obesity, nutrition improvement, and physical activity enhancement have been widely implemented in other countries, but it will first be necessary to understand the Haitian population's use of cell phone, particularly smart phone technology.[110,111]

Physical Activity Transition. Since the beginning of human history, the role of physical activity in daily life has shifted. Humans and other early hominids primarily relied on physical activity for survival; gathering food and water, protection from predation, and opportunities for procreation drove activity.[112] Over time, with the development of technology, advances in sanitation and health care, and the subsequent epidemiologic and economic transitions, humans have experience diminished need for physical activity as related to survival. Now, as nutrition transition fuels changing food environments (to be discussed in greater detail in Section 1.3.3 of this chapter), an abundance of caloric energy is available with minimal physical activity exertion. Instead, in modernized societies, physical activity is sought out more through leisure-time pursuits, for achieving and maintaining a healthy body composition, or via utilitarian activity (*i.e.*, occupational and domestic burdens, though technologic advancements are continually diminishing the need for this kind of activity).[107,112]

Decreased physical activity is associated with increased morbidity and mortality, and thus represents a growing public heath burden (to be discussed in greater detail in Section 1.3.4 of this chapter). As LMICs like Haiti undergo the physical activity transition, it has been projected that the benefits associated with nutrition, epidemiologic, technologic, and demographic transition (*e.g.*, increased life span, increased food availability, decreased infectious disease, increased free-time unrelated to work or survival) will be negated by the detrimental health effects of increased physical inactivity.[107] Physical activity has largely been studied in high-income settings, where the changes in health environments are more static, due to further progression through the various health-related transitions.[113] As LMICs are undergoing rapid transitions in epidemiology, demography, nutrition, and technology due to the ever-expanding nature of global markets, the study of physical activity in Haiti and other low-resource settings will be of great influence in mitigating the negative health consequences associated with the dual burden of malnutrition. Specifically, as technological advances continue to diminish the need for utilitarian activities, understanding the differences in necessity versus choice-driven physical activity as it relates to the home environment, school/work environment, leisure-time, and means of transportation will be necessary to accurately describe and the physical activity behaviors of Haitians and other LMIC populations.

1.3.3 Changing Food Environments

Food Marketing

Rapid globalization and nutrition transition in Latin America and other Caribbean countries has led to rapid increases in food and beverage marketing, primarily directed at increasing consumption in children and adolescents.[114] Concomitantly, Mexico is now ranked as first in childhood obesity rates and SSB consumption.[115] Global and transnational advertising is

now ubiquitous, as companies expand their influence to reach previously untapped revenue streams; in Mexico, the Coca-Cola Company spends approximately 70 million dollars each year.[116] Through lobbying efforts, Mexican corporations have strongly opposed obesity prevention legislation that attempted to regulate exposure to television marketing of fast food and SSBs in children.[117] The efforts of these companies are motivated by brand recognition, which has been directly linked to children's consumption patterns; children consistently display preference for foods with logos and brands over the same products after labelling has been removed.[118] One systematic review reported that 35 out of 45 studies documented significant associations between marketing strategies and greater preference for products.[119] Furthermore, all the marketed foods were of high-caloric and low-nutritional value. The Institute of Medicine reports an unprecedented, statistically significant increase in food marketing directed at children in the last two decades, citing serious long-term health consequences for children.[119]

Indeed, the health consequences of such marketing strategies are tangible. A plethora of literature has demonstrated the association between television viewing, marketing, and children's food and beverage preference, purchasing, and consumption patterns, which, in turn, have been linked to childhood/adolescent obesity, including higher levels of adiposity.[120–122] One study, conducted in laboratory settings, showed that while watching television, children experienced a lower metabolic rate than when otherwise at rest, and children predisposed to obesity experienced a larger drop in energy expenditure.[123] Another study used prospective data and found that the prevalence of obesity increased by 2% for every additional hour of television viewed in adolescents 12-17 years old.[124] And yet another study conducted on the linkage between televised fast-food restaurant advertising and body composition in children and adolescents found that banning such advertising could reduce the number of overweight children

(age 3–11) by 18%, and the number of overweight adolescents (age 12–18) by 14%.[125] This is of significance in Haiti, as television ownership is on the rise (Table 2).[36,37]

Some corporations have attempted to rebrand themselves as purveyors of health and wellness by aligning their marketing with public health campaigns focused on physical activity and active living. For example, Kraft Foods Company has reduced advertising targeting children and adolescents to encourage better eating habits.[126] Additionally, the Coca-Cola Company and Pepsi Co-sponsor large physical activity promotion programs in Latin America, including the Ciclovía program and various school based physical activity programs in Mexico and Brazil.[116,127–129] As previously mentioned, the Coca-Cola Company has a large presence in Haiti.[91,93] Understanding food marketing within Haiti provides an opportunity for intervention in the development of obesity and the dual burden of malnutrition; leveraging media sources to promote healthy messages to the population could help promote available programs and resources and/or public health messages aimed at positive nutrition and physical activity behaviors.

Agriculture and Food Pricing

The most identifiable effect of globalization on the changing food environment is seen through the changes in agriculture and food prices that results from the integration of new food markets into the global economy.[130] Global food prices have been on the rise since 2003, experienced the most dramatic acceleration in 2006, and reached record highs in 2008, which has profound implications for LMICs at the beginning of the nutrition transition continuum.[131] Because of the rapid nature of both increases in global food prices and the nutrition transition in LMICs, the agriculture trade has been forced to undergo an equally accelerated process, causing large-scale, sudden shifts in the nutrition economy.[90,132] One analysis of the effects in LMICs

found this resulted in increased production of animal source foods and related increased use of natural resources. However, population consumption of animal source foods was not found to not immediately mirror the increase in production, creating a gap between supply and demand, and ultimately an imbalanced and less efficient agricultural economy.[132]

One means of dealing with this sudden transition is the implementation of agricultural policies that affect input, production, and trade.[133] These include agricultural subsidies for irrigation, fertilization, pesticides, and infrastructure, all for the purpose of increasing agricultural yields, which ultimately can influence food prices.[130] Food prices in Haiti are strongly influenced by geography, climate, a vulnerability to natural disasters, and the macroeconomic and political environment.[134] In Haiti, the Feed the Future program is a partnership between the Haitian and US government to develop rural agriculture, specifically promoting large-scale staple crops of maize, rice, wheat, mangoes, plantains, beans and cocoa.[135] Through the subsidization of certain crops, governments influence the market, and ultimately the population's diet, by making subsidized food more readily available at affordable prices.[131] For example, these changes have been linked to increased consumption high fat, energy dense foods, as well as decreased consumption of fruits and vegetables, especially in LMICs like as Mexico, Brazil, and Columbia.[1,16,131,136]

1.3.4 Physical Activity

Nutrition and health outcomes are linked to physical activity patterns in addition to diet and the food environment. This has been described as a characteristic of shifting stages in the nutrition transition: changes in dietary structure combined with reduced physical activity brings about increased obesity prevalence.[103] Many different environmental and policy factors have been linked to decreased physical activity, especially the physical environment.[137] The physical

environment includes both the natural environment (e.g., terrain and weather patterns) and the built environment (BE). Environmental changes resulting from globalization, urbanization, and technologic transition have been linked to decreased physical activity.[9,86] Physical activity at home, in the workplace, and during leisure time have greatly declined in the face of technological advancement that increased convenience, but decreased the energy expenditure required for cooking, cleaning, commuting, and communicating. The impact of BE on physical activity has been increasingly examined in the last decade.[138] The literature comes primarily from two fields; urban planning chiefly examines travel behavior, and public health largely examines physical activity.[139] The existing literature from both fields has substantiated the linkage between BE and physical activity, but is diverse in scope and measure, and thus identifying the strongest associations have proven difficult. Yet, areas of opportunity for further intervention study have been identified, and will prove useful in determining the role of the physical activity and BE in the dual burden of malnutrition: land use, accessibility, transportation infrastructure, and attitudes and motivations.[138–141]

Studies of correlates of physical activity largely have been undertaken in high-income settings, with some original studies focusing on LMICs, though nearly all focused on middle-income countries.[113] In addition to the aforementioned areas of study, understanding the variance in physical activity levels amongst different demographic groups within LMICs will prove necessary in understanding the interplay between physical activity the dual burden of malnutrition. Previous literature has established that physical activity levels in LMICs are lowest amongst women, ethnic and racial majority, those of higher education and income levels, those in urban settings, and the elderly.[142] This variance is particularly applicable to the phenomena of

the dual burden household, where physical activity levels and food distribution within the household may vary from one family member to another.

Research has shown that factors related to nutrition transition and the dual burden of malnutrition are also correlates of physical activity in adolescents. Parental factors, SES, sedentary time while watching tv, environmental milieu, and diet have all been linked to adolescent physical activity, though the findings are varied and inconsistent.[113,143–146] The majority of research has been conducted in high-resource settings, calling into question the relevance of these findings in a low-resource context in LMICs, where cultural, environmental, and demographic factors differ from those in developed countries.

Literature examining physical activity in Haiti is extremely limited. In fact, the EMMUS DHS survey in Haiti does not report physical activity levels.[36–38] A database search revealed only one study published to-date related to physical activity in Haiti, which was a pilot study examining the effects of yoga on the reduction of emotional and behavioral difficulties in children living in an orphanage after the 2010 earthquake.[147] The lack of study is likely attributable to Haiti's early stage in nutrition transition, including the persistence of undernutrition and its comorbidities. Future promotion of physical activity within Haitian children and adolescents first requires an understanding of baseline physical activity levels; needs assessments and physical activity monitoring are essential to effective intervention. Physical activity interventions must be culturally and contextually appropriate, calling for both a qualitative and a quantitative understanding of current physical activity attitudes, beliefs, and behaviors within Haitian adolescents.

1.4 Conceptual Frameworks

The drivers of nutrition transition represent a wide array of risk factors for the dual burden of malnutrition, with some aspects more closely associated with the manifestation of either extreme of malnutrition. It is necessary to recognize that, in consideration of this proximal-to-distal array of risk factors, not all elements provide actionable opportunities for intervention, but rather are necessary for characterizing the dual burden and conceptualizing effective policies and programs within these contexts. No problem exists in a vacuum, and as such public health has long drawn on the ecological framework to understand phenomena like nutrition and physical activity.[148,149] Thus, an adequate and useful conceptual model must consider the context of the nutrition transition, and its effects on the dual burden of malnutrition. Globalization, urbanization, and the various other transitions associated with nutrition transition represent distal, contextual risk factors for the dual burden. Food marketing, agriculture, food pricing, and physical activity behaviors all represent more proximal risk factors with applicable points of intervention. What follows is a discussion of other proximal risk factors as well as associated frameworks and theories for understanding the dual burden, which together can guide the planning and implementation of public health interventions addressing both underweight/stunting and overweight/obesity.

1.4.1 Socioeconomic and Cultural Determinants

Poverty and Inequality

Socioeconomic Status. The negative association between SES and undernutrition has been consistently observed in LMICs.[150–153] One measure of SES is household income. Children and adolescents in low-income households are more likely to be undernourished than their high-

income household counterparts. This negative relationship is attributable to the association between low income and inadequate access to food, health care, limited sanitation, and potable water—all of which have been linked to negative health and nutrition outcomes.[151,154]

In LMICs, the relationship between SES and overweight/obesity was previously considered to be directly proportional; as SES increased, BMI increased, however, in light of rapid nutrition transition, an inverse relationship between SES and BMI has emerged.[155–158] More recent studies have shown that, as a country's economic indicators improve, the prevalence of overweight and obesity shifts to and becomes disproportionately nestled within the urban poor population.[157] This is partially explained by the link between low SES and residing in urban high crime neighborhoods resulting in a lack of safe outdoor play areas and increased sedentary leisure-time activity indoors.[159]

Maternal Factors. Maternal factors associated with poverty and inequality are also important in considering a child's health and nutrition. Low maternal education—independent of household income—has been directly linked to childhood undernutrition.[160,161] As educational level attained by the mother increases, so does the likelihood of positive health and nutrition outcomes for the child. This is due to the association between maternal education and the implementation of proper care and feeding practices.[160,161]

Family and Social Context

Family Context. Familial factors are considered to be the largest determinant of children's health and nutrition outcomes, as children depend upon their parents for the provision of food.[119] Parental feeding practices predict the type and amount of fruit and vegetables, dairy products, and sugar-sweetened beverage consumption in children.[162–165] In addition to maternal education, work status of the mother has important implications for feeding practices and child's

nutrition outcomes. One study showed that children whose mothers work full time have lower quality and decreased variety of diet; consumption of fiber and iron decreased, while consumption of soda and packaged food increased.[166] Maternal working status is also linked to increased rates of eating outside of the home, which is linked to negative nutrition outcomes, as restaurant foods are often higher in saturated fats, salt, and refined sugars.[16] It is interesting to note while increased maternal education increases the implementation of positive feeding practices, it also increases the likelihood of employment status, which can diminish the beneficial effects of education, in that the time away from home for work leads to lower quality of diet.

Social Context. Social conditions in the household, neighborhood, and school environments play important roles in childhood nutrition status. As previously mentioned, proper sanitation, access to potable drinking water, and safe play areas around the home and neighborhood have important implications for diet and physical activity practices. Feeding practices are largely influenced by the school context, as approximately 20-50% of children's daily caloric intake comes from school cafeterias and vending machines.[119] Government-sponsored feeding programs are increasingly common in LMICs, which provide free or reduced-cost meals (breakfast, lunch, or both) to children/adolescents during the school day. While these programs have shown promise in addressing certain aspects of undernutrition, many of the foods provided are low in micronutrients and high in saturated fats, salt, and refined sugars.[119] The poor nutritional value of these foods does not provide adequate supplementation to alleviate undernutrition related to stunting, and instead can exacerbate issues of overweight and obesity.

1.4.2 A Social-Ecological Framework of the Dual Burden of Malnutrition

Until the latter part of the 20th century, the social and cultural determinants of disease were largely ignored in research. In 1985, work by the epidemiologist Geoffrey Rose related social inequalities to disparate incidence rates of disease.[167] Since that time, social-ecological frameworks of disease are widespread in their use for guiding program and policy implementation. As previously discussed in this chapter, work by Stewart and colleagues in 2013 detailed the context, causes, and short- and long-term consequences of stunted growth and development related to undernutrition (Figure 1).[65] This social-ecological model has many strengths in understanding the dual-burden of malnutrition, but is limited in application to just one extreme of malnutrition as it does not address obesity. In 2009, Leslie Lytle proposed a concept model of the etiology of childhood obesity, diagraming the contextual, behavioral, and biological factors that related to obesity risk.[168] Again, this model is useful in addressing one aspect of the dual burden, but it does not address health consequences, nor does it have applicability to undernutrition.

This dissertation proposes a modified model addressing both undernutrition and overweight/obesity, including short- and long-term health consequences for children and adolescents. The model is a composite of the work by Lytle and Stewart and colleagues (See Figures 1.2 & 1.3). The need for this model arises in the face of addressing rapid nutrition transition within LMICs and the emergence of the dual burden of malnutrition. As the causes of childhood and adolescent undernutrition and obesity are multifaceted and socially complex, this concept model of the dual burden of malnutrition in youth draws on the previous discussion of the socioeconomic and cultural determinants of health. It uses a social-ecological perspective, and considers variables of poverty and inequality, family and social context, as well as diet and

feeding practices within the framework of individual factors such as age, sex, psychosocial, and biological factors.

The model is designed to be both neutral and broad guide to guide a wide range of programs and policies. The model is neutral in that it is not directed towards a specific health outcome, but instead accounts for either manifestation of malnutrition, examining both short-term and long-term correlates and outcomes related to BMI percentile and body composition. The model is broad in that it accounts for the interactive, mediating, and moderating effects of certain factors across model levels. The model posits that factors like demographics and family history and structure act as effect modifiers across multiple levels, while directly influencing the child's contextual factors of individual psychosocial factors, socioenvironmental factors, and physical environmental factors. Psychosocial factors account for variables intrinsic to the child, such as self-efficacy, cognition, self-esteem, etc. The socioenvironmental and physical environmental factors are comprised of complex, transdisciplinary variables extrinsic to the child. These three contextual factors influence behavioral and biological factors such as diet, physical activity, and extrinsic health conditions (*e.g.*, presence of illness) and behaviors (*e.g.*, sleep quality), which account for maternal behaviors in addition to those of the child. Intrinsic biological factors of metabolism, pubertal status, and blood chemistry directly influence and are influenced by the child's BMI percentile and body composition, ultimately manifesting in positive or negative short- and long-term health consequences.

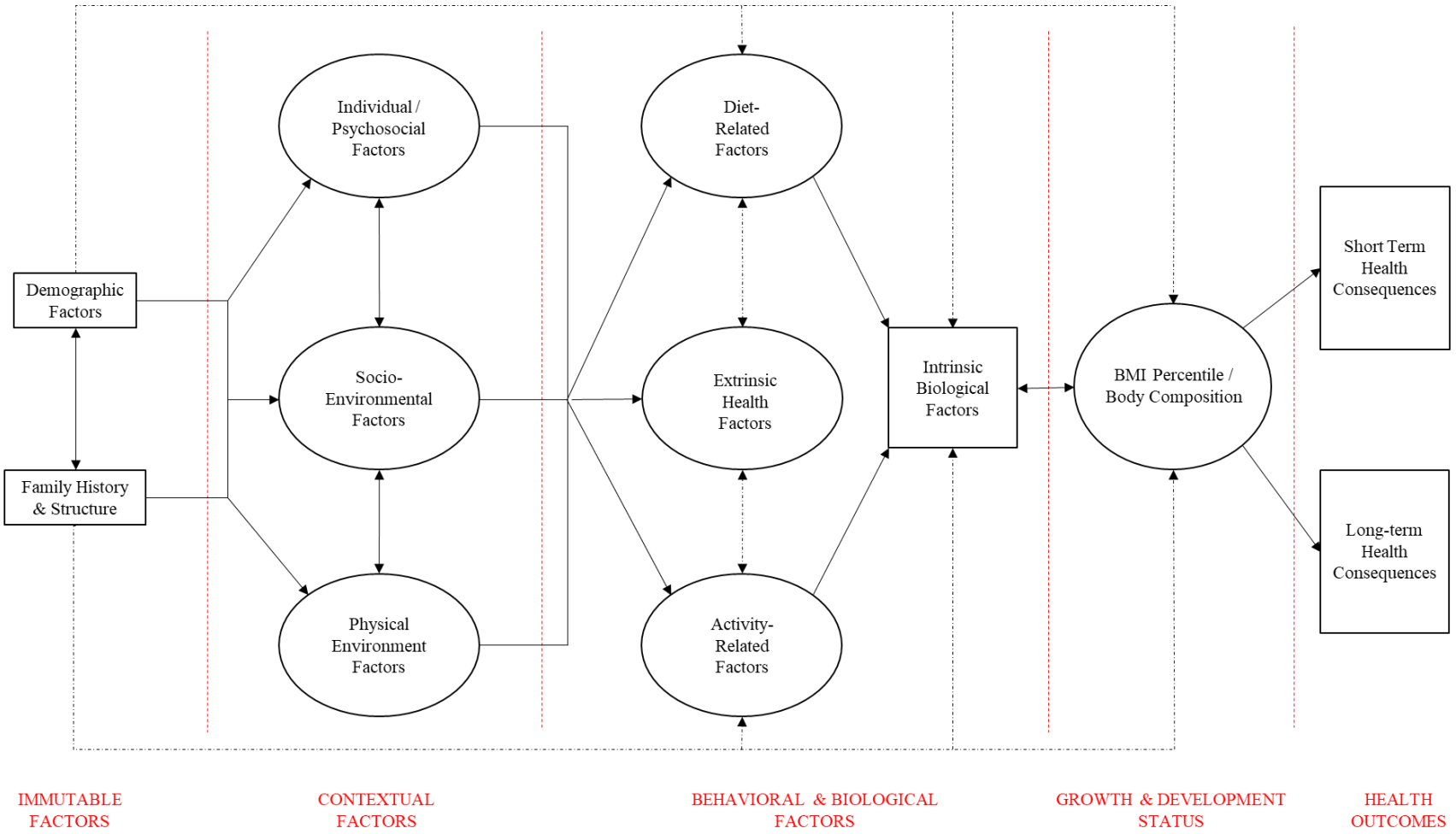

Figure 1.2. *Concept model: Etiology of the dual burden of malnutrition*

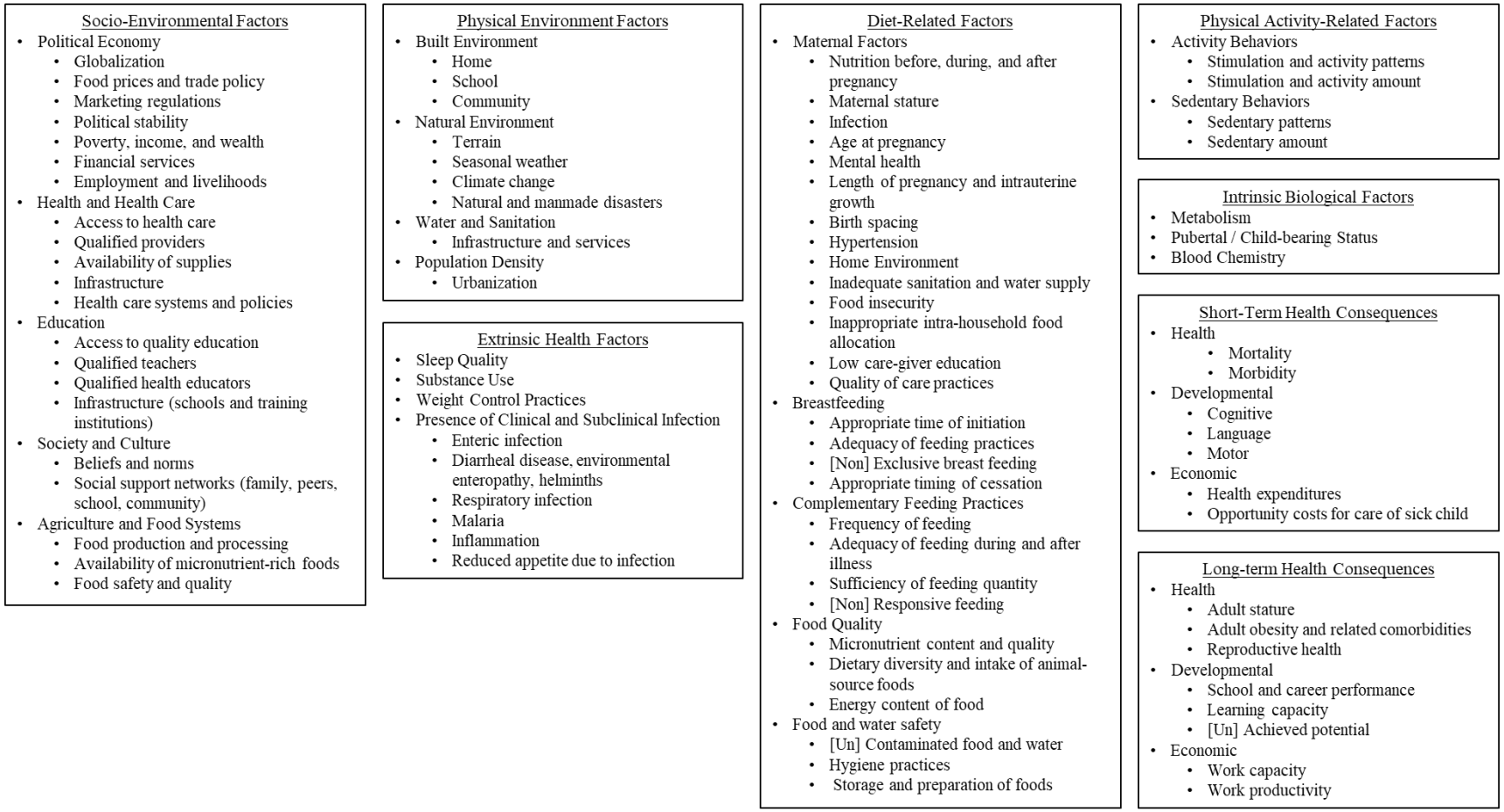

Figure 1.3. *Variable definition for "Concept model: Etiology of the dual burden of malnutrition"*

1.4.3 The Thrifty Phenotype Hypothesis and Fetal Programming of Disease

The thrifty phenotype hypothesis, first introduced in 1992, posits that there is an epidemiological association between poor fetal and infant growth and subsequent development of glucose intolerance and metabolic syndrome in adulthood.[169] The intrauterine environment, largely determined by maternal health and nutrition, effects fetal growth hormones and the development of key organs and organ systems.[57,169] If the intrauterine environment is undernourished due to maternal malnourishment, certain fetal metabolic changes and adaptations occur in order for the survival of the fetus, specifically in regards brain development.[170,171] This results in metabolic deficits that are carried into birth, childhood, and later in life.[57,169]

Children experiencing fetal undernutrition may also experience any of the following adaptations: intrauterine growth restriction, LBW, reduce insulin secretion, or insulin resistance.[66,172] If a child remains in a micronutrient and calorie-depleted environment after birth, any of these adaptations may prove beneficial. However, when these adaptations are combined with weight gain, aging, or physical inactivity, the child incurs greater risk of developing NCDs later in life.[61] Indeed, if the postnatal environment is higher in nutrition intake than the environment forecasted by maternal nutrition and metabolic status during pregnancy, these fetal metabolic adaptations can bring about obesity, cardiovascular disease, hypertension, and Type 2 diabetes mellitus.[58,66,169,172,173] Understanding fetal programming of NCDs through the thrifty phenotype hypothesis emphasizes the importance of maternal pre- and post-natal nutrition.[63] This has important implications for the implementation of programs and policies directed at reducing the dual burden of malnutrition.

1.4.4 Catch-up Growth and Adolescence

Catch-up growth is defined as the attainment of a healthy BMI in late childhood or adolescence following thinness at birth or during early childhood.[174] Catch-up growth mediates the relationship between LBW, physiological alterations caused by the thrifty phenotype, and DR-NCDs.[59,60] The physiological alterations that result from fetal undernutrition result in LBW and a thrifty phenotype, characterized by a reduced capacity for insulin secretion and increased capacity for insulin resistance, both aimed at maintaining bodyweight in a nutrient-poor environment.[61] Insulin is the peptide hormone responsible for the transport of blood glucose into cells, providing the body with energy. When blood glucose remains high, excess energy is converted into fat storage. Insulin is a major promoter of growth *in utero*.[61] As such, in a nutrient poor environment, the fetus will decrease the amount of insulin produced and/or tissues will become desensitized to insulin, in order to promote the deposition of fatty tissue in order to sustain basic metabolic processes within the body. When an underweight infant is provided with adequate nutrition, catch-up growth occurs.[174]

Research has identified the adolescent growth spurt as an important period for further exploration into the relationship between catch-up growth and reversal of previous nutritional inadequacies, mitigating the risk of adult chronic disease.[53] Adolescence is defined as ages 10-19 years, with ages 10-15 comprising early adolescence.[53] It constitutes a highly vulnerable period for either repairing or further exacerbating the effects of childhood malnutrition; adolescents are considered a nutritionally vulnerable group based on their high requirements for growth, eating patterns, lifestyles, risk-taking behaviors, and susceptibility to environmental influences.[53] This is also a significant period for cognitive growth, including the development of advanced reasoning skills, abstract reasoning, and meta-cognition.[175] Because of this brain development,

adolescents experience increased autonomy with age, and thus are in the process of developing life-long preferences and habits, indicating that behavior change interventions in this group are a strategic investment in adult health and well-being. Thus, adolescence marks a critical opportunity for intervention in the dual burden of malnutrition. Unfortunately, data regarding adolescent health (e.g., stunting, wasting, overweight, and obesity rates; nutrition behaviors; physical activity behaviors; etc.) are unavailable for Haiti's youth.[36–38]

Evidence from dual burden research recommends increased physical activity, paired with appropriate energy and nutrient consumption, to mitigate the long-term health consequences of the dual burden.[10] As catch-up growth tends to favor the deposition of fat over lean tissue, physical activity during adolescence may mitigate the onset of obesity through the development of lean muscle mass.[62] Building lean muscle mass can benefit both extremes of malnutrition, helping undernourished and overweight/obese individuals achieve and maintain a healthy body composition. Furthermore, it has been well established that even modest exercise has been linked to the prevention of the metabolic deterioration associated with a sedentary lifestyle.[176–178] However, a proper balance of physical activity and energy supplementation is necessary, as the need for fat mass in undernourished children cannot be disregarded.[179] Indeed, physical activity interventions related to the dual burden of malnutrition should maintain sensitivity to the culture to conserve energy in typically undernourished populations.

As adolescence is marked by the school-age years, school-based interventions are a logical setting for physical activity interventions.[53,180] Additionally, the school setting represents an opportunity for sustainable intervention, as it continuously exposes adolescents to dietary and physical activity factors.[180] Previous nutrition work in Haiti has shown schools to be a useful venue for gaining access to and affecting change in the health status of children and

adolescents.[32,179,181] While a large body of evidence exists for effective school-based obesity prevention in adolescents in high-income settings, heretofore no such studies have been carried out in Haiti and little is available from Sub-Saharan African countries like Benin, Ghana, and Congo, countries with which Haiti shares a similar genetic ancestry and epidemiological trends.[40,180,182–185]

1.5 Research & Evaluation: Issues & Challenges

In the development of future programs and policies pertaining to the dual burden of malnutrition, it is necessary to consider the areas in need of improvement in past research and evaluation. An important distinction between research and evaluation must be addressed. Research is scientific inquiry conducted in controlled settings, produces generalizable information to advance broad knowledge and theories, ultimately providing the basis for drawing conclusions.[186] Evaluation determines the merit or worth of policies and programs, is conducted within an uncontrolled environment (*e.g.*, changing actors, priorities, resources, and timelines), and provides information for decision-making within program and policy management.[186] Simply stated, research asks, "What is it?" or, "How does it work?" Evaluation goes one step further to inquire "Is it valuable?" or, "How well does it work?"

In the development of our understanding of the dual burden of malnutrition within LMICs—specifically within Haiti—research and evaluation will be important tools in the hands of researchers and educators to gain insight into new domains and to assess the efficacy and efficiency of policies, programs, and methodologies. Making use of the differences in their form, purpose, and content will achieve different goals. Research on the dual burden of malnutrition will generate new hypotheses and theorems for better understanding its causes and effects. Results of this will ultimately be applied to pilot projects and other intervention research, in

order to identify programs and policies that will mitigate growing rates of obesity and persistent prevalence of undernutrition. The role of process and impact evaluations will be to develop systematic approaches for the planning, implementation, and evaluation of programs and policies to enhance effectiveness. However, as yet, a dearth of systematic process and impact evaluations on pilot projects and other intervention research exists, which has prevented the accumulation of "lessons learned" to apply to future work, which in-turn has precluded the scaling up of effective programs.[187]

1.5.1 Issues of Measurement

Measurement of Undernutrition

Several different approaches to measuring undernutrition are acceptable. Undernutrition can be quantified through measures of physical growth and development as well as through measure of food consumption and dietary quality. Physical growth and development have been measured using various interpretations of anthropometric references. Food consumption and dietary quality have been measured through per capita food availability and supply of macronutrients, dietary reference intakes (DRIs), and dietary diversity index (DDI).

Anthropometric measures are the most commonly used indicator of undernutrition. These include weight-for-height (underweight), height-for-age (stunting), and weight-for-age (wasting).[51] Prior to 2006, standard use and interpretation of anthropometry was not established. The Composite Index of Anthropometric Failure (CIAF) was developed with the purpose of providing a more robust classification for the causes of undernutrition, in that it combined wasting, stunting, and underweight, rather than consider them as three independent entities.[188] The goal was to identify all undernourished children, be they stunted and/or wasted and/or underweight.[50] Though the CIAF does potentially offer a more complete picture of

undernutrition, it has been criticized for lacking the use of a clinical classification, providing a universal classification for both community and clinical healthcare workers.[189]

In 1994, the WHO deemed it necessary to establish a single international standard that represents the best description of appropriate physiological growth for all children from birth to five years of age.[48] The Multicenter Growth Reference Study (MGRS) was undertaken between 1997-2003, and the produced the first set of WHO Child Growth Standards (i.e. length/height-for-age, weight- for-age, weight-for-length, weight-for-height and body BMI-for-age) in 2006.[48] The MRGS also established the breastfed infant as the normative model for growth and development.[48] Since this time, the WHO Child Growth Standards are the definitive benchmark of physical growth and development in children 5 years and younger.

Undernutrition can also be quantified through food intake and diet quality. The Food and Agriculture Organization of the United Nations (FAO) commonly uses measures of per capita food availability, which is an estimate of the number of households that do not achieve the recommended daily caloric intake levels required for a healthy energy balance, and per capita supply of macronutrients, which is an estimate of dietary energy consumption (*i.e.*, energy, protein, fats) per person.[190] These measures are still in use, but are most appropriately applied to larger units of analysis (*e.g.*, states, regions, countries), rather than to smaller units (*e.g.*, the individual or household level).

Measuring nutrition intake for smaller units of analysis can be quantified through use of a DRIs and DDIs. There are several different DRIs, all of which are reference values that are quantitative estimates of nutrient intakes used to plan and assess diets for healthy people.[191] The four DRIs are: Recommended Dietary Allowance (RDA), which is the average daily dietary intake level that is sufficient to meet the nutrient requirement of 97-98% of healthy individuals in

a group; Adequate Intake (AI), which is an approximation of nutrient intake by healthy people based on observed or statistically inferred values used when RDA cannot be determined; Tolerable Upper Intake Level (UL), which is the highest daily nutrient intake level likely not to post risk of adverse health effects to most individuals in a population; and Estimated Average Requirement (EAR), which is an estimate of the nutrient intake value required to meet the necessary intake for 50% of the healthy individuals in a group.[191] Prior to the 1997, RDAs were the only nutrient reference standard. In 1998 the Food and Nutrition Board of the Institute of Medicine began releasing the other DRIs, with periodic updates for their application.[192–197] A practice paper from the American Dietetic Association provides guidelines for applying the DRIs and assessed their use with both individuals and groups of people. The paper found the DRIs allowed better assessment of nutrient intake and planning of nutritionally adequate diets.[198] It also recommended the incorporation of DRIs into training and practice, recognizing the potential for improved health outcomes.[198]

A DDI is a measure of the number of individual foods or food groups consumed in a given time period. It can reflect household access to a variety of foods and can also act as a proxy for individual nutrient adequacy.[199] The household dietary diversity score (HDDS) is a cross-sectional assessment of the economic ability of a household to access a variety of foods. Research has shown that increased dietary diversity is associated with increased SES and household food security.[200,201]

Individual dietary diversity scores measure nutrient adequacy; a higher DDI score is related to increased nutrient adequacy of the diet, a proxy measure for macronutrient and micronutrient adequacy that has been validated across several different age and sex groups. Higher DDI scores have been positively linked to appropriate micronutrient and macronutrient

consumption in infants, young children, adolescents, and adults.[199] To date, an international consensus on which food groups to include in the scores at the individual level for different age and sex groups is not yet established. Work under the Nutrition and Consumer Protection Division of the FAO with support from the European Union set out general guidelines for measuring dietary diversity, providing a standardized questionnaire with universal applicability from which various dietary diversity scores can be calculated.[199] The guidelines allow for field adaptation of the questionnaire to accommodate different cultures, populations, and locations.

Measurement of Obesity

Measures of obesity are based on calculating body fat percentage (BFP). The most common measures include BMI, bioelectrical impedance (BIA), and waist circumference (a measure of abdominal obesity—the central distribution of adiposity on the body). BMI is a very limited indicator of obesity, especially when self-report height and weight are used.[202,203] Furthermore, BMI is an indirect measure of body composition compared to BIA, as the latter accounts for muscle mass and better reflects the physiological changes that occur with age (e.g., muscle mass decline, loss of bone density, loss of height).[203] Finally, the relationship between BMI and BFP is non-linear and varies for the sexes, and when combined with failure to account for nonfat mass (e.g., bone and muscle), this lends to the false assumption that two individuals with identical BMI would have identical BFP.[203]

Understanding fat mass (FM) vs fat-free mass (FFM) is helpful in assessing overall health and risk for chronic diseases, providing accurate nutritional counseling, designing and monitoring the efficacy physical activity for weight problems, and monitoring the growth and development of children and adolescents. Other measures of body composition have proposed, including two-, three- and four-compartment models of body composition that account for FM vs

FFM.[82] The traditional two-compartment model compares FM to FFM using BIA. The three-compartment model measures FM, total body water (TBW), and fat-dree dry mass. The measure of TBW is based on a constant mineral-to-protein ratio.[204] The four-compartment model measures FM, TBW, bone mineral mass (BMM) and residual body mass, and requires used of dual-energy X-ray absorptiometry (DEXA) to capture BMM. A comparative analysis done by Withers and colleagues in 1998 evaluated the accuracy differences between the three models. Results showed that the three-compartment model to be more valid than the two-compartment model, but that the four-compartment model added little extra accuracy.[82]

Though BMI fails to capture FM vs FFM, it remains widely in use in the social sciences due to its simplicity. Measuring an individual's height and weight is easily accomplished in field work, and it does provide a moderately accurate measure of one's body composition. Other methods of measuring BFP are significantly more accurate but require more resources and are far less convenient; CT, MRI, and DEXA scans more accurately measure body fat, but require more time, money, and equipment. Measuring BIA is far less time consuming, but equipment is still moderately expensive compared to that needed for BMI. And though BIA does account for nonfat mass, measurements are still subject to inaccuracy, as the measure does not account for levels of hydration or location of body fat. Waist circumference has been identified as a strong predictor of metabolic disorders and cardiovascular risk, but does not provide a full picture of the scope of adiposity, as it does not account for body fat that is not located on the abdomen.[202] Summarily, the use of BMI as a measure of obesity can introduce misclassification problems that may result in important bias in estimating the effects related to obesity, but as long as more accurate measures of body fat and body composition remain costly, BMI will remain the primary

measure. For study in Haiti, BMI is the most reasonable measure of body composition due to the low-resource context in which research would be conducted.

Measurement of Physical Activity

Physical activity is complex construct requiring varied measures to capture its many aspects. No single measure is the most appropriate for physical activity. Instead, the measure (or measures) most appropriate for the context in which physical activity is being examined should be used. Measures of physical activity include the self-report questionnaires, self-report activity logs (also called diaries), direct observation, device-based measurement, and the doubly-labeled water (DLW) method. These data collection methods can elucidate the duration, length, intensity, and frequency of physical activity.

The DLW method is considered the criterion standard for measuring energy expenditure. The method measures the exponential disappearance of the isotopes ^{2}H and ^{18}O from the body after a bolus dose of water labeled with both isotopes has been administered; hydrogen isotope is lost as water, and the oxygen isotope is lost as either water or carbon dioxide.[205] The rate of disappearance can be used to estimate total energy expenditure using a respiratory quotient and indirect calorimetry.[206] While extremely accurate, this method is time consuming, expensive, and employs some broad assumptions that undermine the universal application of its findings.[206]

Self-report questionnaires vary based on the nature of activity being assessed (e.g., frequency, patterns, or duration of physical activity), the operationalization of physical activity (e.g., time in minutes, calories expended), and collection style (e.g., paper, computer, or interview assessments).[207,208] Self-report questionnaires have been shown to be valid and reliable.[209] They are advantageous to other methods in that they are easy to administer and are

highly-cost effective.[210,211] However, self-reported questionnaires have limitations including social-desirability bias in reporting, limited responses based on the nature of the language of the questions, and literacy issues.[212–216]

Participants can record their physical activity in real time using self-report activity logs, or diaries of physical activity.11 This method provides more detailed data than self-report questionnaires and helps to circumvent issues of bias (e.g., recall, social desirability, or measurement).[217,218] However, limitations include adherence to logging, the Hawthorne effect, memory bias if not filled out in real-time.[219,220] The cost-effectiveness of using physical activity logs is approximately equal to that of self-report questionnaires. Deciding between the two methods is at the researcher's discretion based on the level of complexity desired in the data, cognitive capacity of the participants, and length of exposure to the sampled population.

Direct observation methods are applicable to activities occurring in a defined/delineated space (e.g., playground, gymnasium, or park).[221,222] An independent observer monitors and records physical activity behaviors, gathering contextual details. This method is considered very flexible and is more qualitative in nature. Information detailed can include type of physical activity, time, location, weather, equipment used or clothing worn, descriptions of social interactions surrounding the activity, or personalized variations in activities performed. This method is advantageous in its provision of contextual information typically not captured in any other collection methodology. However, it has various limitation, including the Hawthorne effect, challenges to participant consent, high time-cost on the part of the observer, and lack of universal, objective measures for energy expenditure.[219,220,223]

Device-based measurement comes in many forms. Devices include accelerometers, pedometers, GPS units, and heart-rate monitors. Accelerometers measure acceleration (counts) in

real time and detect movement in up to three orthogonal planes (anteroposterior, mediolateral, and vertical).[223,224] The counts can be translated into different metrics for assessing energy expenditure or physical activity level (e.g., sedentary, moderate physical activity, vigorous physical activity).[225] Devices can be worn on the hip, waist, or thigh.[226] Accelerometers are advantageous in that they accurately and objectively assess physical activity, without subject to many of the biases mentioned above. However, they are expensive, require technical expertise, specialized software and hardware, lack contextual information, and can be unreliable in determining body position (e.g., sitting, standing, or lying down).[220,227] Also, cut-point of counts to determine physical activity level are subject to variability, and thus can create variability in the intensity of measured physical activity.[228]

Pedometers employ a horizontal, spring-suspended lever to measure number of steps taken. Pedometer measurements are highly correlated with measurements from uniaxial accelerometers.[223,226,229,230] Pedometers are advantageous in their simplicity, low-cost, and ability to pick up short bursts of physical activity that would otherwise be overlooked in self-reported methods. Pedometers are limited in that they do not record intensity, frequency, or duration of physical activity as well as their inability to record physical activity in a horizontal motion (physical activity that may occur while sitting or that only involves upper body movement).[230–232] They are also prone to the Hawthorne effect.[219,223,233]

GPS units provide location-based information regarding physical activity relative to major landmarks in the participants environment. These units are advantageous in that GPS provides a unique, contextual assessment of physical activity, however, does not measure physical activity directly. Though the GPS provides speed, it's not an accurate assessment of individual physical activity. GPS units are limited by data loss due to noncompliance, battery

power, and signal. Also, they have high resource requirements; use of the units necessitates technical expertise, specialized hardware and software, funding to purchase expensive equipment and licenses, and time to program and validate the data.

Heart-rate monitors provide a physiological measure of physical activity, capturing frequency, duration, and intensity of energy expenditure.[226,234] Heart-rate monitors are advantageous in that they are unobtrusive and require low effort on the part of the researcher or participant.[235–237] Heart-rate monitors are limited by discrepancies in measurement during extremely high and extremely low periods of activity.[231,236–239] Age, body composition, muscle mass, gender, and fitness level also affect this linear relationship or reduce its accuracy.[232]

Given that further research is needed to validate individual physical activity measures for different populations, it is difficult to determine an optimal physical activity assessment. Thus, investigators when selecting a physical activity measure need to pay close attention to each assessment's strengths and limitations.

1.5.2 Process & Impact Evaluations

There is increasing demand for evidence of effectiveness as a requirement to inform health promotion practice and assist policy makers in decisions concerning resource allocation. This evidence-based approach calls for increases in both quantity and quality of process and impact evaluations. Translational research is most practical method of evaluating nutrition programs, as operational and ethical reasons would prohibit the use of randomized-control trials in most scenarios. Because of this, natural experiments are tenably the most practical option for evaluating nutrition programs.

In order for evaluation through natural experimentation to be effective, a number of conditions must be met: the research question should be of high-priority to the organization, with

a strong organizational consensus around the need for impact evidence; a review of available evidence should demonstrate that there are knowledge gaps worth filling; a commitment must be made to acting on the results of the evaluation; the program should be sufficiently mature with a strong monitoring and evaluation systems in place, including the appropriate selection of indicators for evaluation; and finally, the costs of conducting an evaluation should be justified relative to its benefits, with both costs benefits clearly defined prior to the evaluation.

1.6 Mitigating the Dual Burden of Malnutrition in Haiti

1.6.1 Current Nutrition Programs

Myriad nutrition programs and policies have been implemented in LMICs across the globe in an effort to assuage both the acute and chronic effects of undernutrition. The scope of these programs and policies is vast, ranging from targeting populations most in need, to universal application within a particular setting (e.g., geographic region, patient registry). These programs and policies take many forms but fall under two main classifications: nutrition-specific or nutrition-sensitive. Nutrition-specific programs and policies are those which have a direct impact on the immediate causes of undernutrition, such as inadequate food intake, poor feeding practices, and high burden of disease. Examples of nutrition-specific programs and policies include support for breastfeeding, complementary feeding, micronutrient supplementation and home fortification, disease management, and treatment of acute malnutrition and nutrition in emergencies. Nutrition-sensitive programs and policies are those that seek to integrate and promote nutrition as a goal across multiple sectors in order to accelerate national development. Examples of nutrition-sensitive programs and policies include those that incorporate agriculture, social protection, maternal and child health, child development programs, physical activity, behavior change, and education.

The following is a review of current nutrition programs and policies applicable to the prevention of the dual burden of malnutrition in Haiti. As many program and policy evaluations are not amply available in peer-reviewed and grey literature, this dissertation recognizes the plethora of programs/ and policies that may not be well-documented, and thus unavailable for review. As a full literature review is beyond the scope of this dissertation, large-scale public (i.e., government) and private (i.e. non-governmental, or NGO) nutrition and physical activity programs and policies in Haiti were selected for review.

After the 2010 earthquake, which exacerbated existing challenges of poverty and malnutrition, the Haitian government took action to improve nutrition and food security through the implementation of a national policy, ABA Grangou.[240] ABA Grangou is designed as a strategic framework with two concurrent goals: 1) halve the proportion of people suffering from hunger by 2016; 2) eradicate hunger and malnutrition by 2025. The national-level Commission for the Fight Against Hunger and Malnutrition (COLFAM) is responsible for the strategic direction of the ABA GRANGOU and is chaired by the First Lady.[241] The National Coordination Unit of ABA GRANGOU (UNAG) is responsible for execution and coordination of the activities set out in the national framework. COLFAM oversees the nine ministries, the seven autonomous agencies, the Haitian Red Cross (HRC) and the 21 government programs working on ABA Grangou.[240,241] The three strategic focus areas include social safety net programs to improve access to food for the most vulnerable; agricultural investment programs to increase domestic food production; and programs that deliver essential services to the most vulnerable families, including health and nutrition, improved water and sanitation infrastructure, and crop storage.[240]

A second policy change came in 2012, when Haiti joined Scaling Up Nutrition (SUN). The SUN Country Network provides an opportunity for SUN Government Focal Points to share

experience, providing an opportunity for countries to seek advice or assistance, enabling engagement in issues that cannot be addressed in-country, as well as analyses of their country's progress in scaling up nutrition.[242] The Network meets through a series of conference calls every twelve weeks and an annual gathering. Regional meetings take place when the opportunity arises. The SUN Country Network consists of a global movement to unite national leaders, civil society, bilateral and multilateral organizations, donors, businesses, and researchers in a collective effort to improve nutrition.[242] Partnering with SUN, Haiti has identified three priority commitments for scaling up nutrition: 1) high level advocacy (international visibility); 2) improvement of the coordination of the different stakeholders; and 3) resources mobilization.[243] Additionally, Haiti is working to strengthen its human resources capacity for nutrition in response to the services gap created by the departure of NGOs temporarily present after the earthquakes in 2010; specifically, eight executive personnel have been appointed to ten different departments.[243] To date, there is no specific donor assembly identified for Haiti.[243]

Haiti participates in Feed the Future, the US Government's global hunger and food security initiative.[244,245] Feed the Future consists of a multiyear plan emphasizing rural growth and income generation—namely through agricultural development, with provisions for Haiti's challenging topography and microclimates.[244,245] Feed the Future focuses on three development areas (referred to as corridors); two of the corridors extend from Port-au-Prince to St. Marc, and the third covers the North and Northeast regions.[245] Feed the Future has two nutrition-specific projects: the Nutrition Security Program (NSP) and the Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING) project.

The NSP was launched in 2013 with the goal of improving the nutritional status of children and pregnant and lactating women in Feed the Future's three geographic focus

corridors.[246] Specifically, NSP aims to achieve a 5% reduction in the prevalence of underweight among children under 5 years of age. The project relies on a holistic community health, nutrition, and livelihoods approach that works through local NGOs. The approach uses Care Groups, which trains local leaders who then provide key health and nutrition messages to their communities.[246,247] The motivation of this approach is to develop new health and nutrition care groups in addition to the existing government health and nutrition systems. Anticipated results include improved nutrition behaviors through essential nutrition actions, improved access to and consumption of a diverse and quality diet, and increased livelihood opportunities for vulnerable households.[246,247]

The Haitian government launched the Food and Nutrition Technical Assistance (FANTA) III project to assist in meeting nutrition-related goals outlined in the NSP.[248] It closed in December of 2013, within the first year of the project, but was responsible for promoting the integration of nutrition assessment, counseling and support (NACS) into HIV programs; using an advocacy tool called PROFILES to analyze costs and consequences of nutrition deficiencies and interventions; developing a social and behavior change communication strategy (SBCC) to promote improved nutrition practices among vulnerable adults and adolescents; and strengthening food security and nutrition surveillance systems to improve responses to emergencies.[248]

The SPRING project is a broader national program, not limited to the Feed the Future focus corridors. SPRING has two predominant goals: 1) to support facility-based NACS, especially for pregnant and lactating women and children under 5 years of age; and 2) to strengthen the referrals made between community groups and health facilities.[249–251] SPRING also works to harmonize national and donor SBCC tools and related training in facilities on

nutrition topics that fall under Essential Nutrition Actions.[251] In 2012, SPRING organized a national stakeholder's meeting on NACS, conducted a NACS services assessment in health facilities, and developed a facility-based on-the-job training package on Infant and Young Child Feeding.[249,251]

USAID/Haiti has a nutrition-related development program, Food for Peace Title II, which partners with ACDI/VOCA, Action Contre le Faim (ACF), CRS, CARE, World Vision, and WFP to implement assistance activities including food vouchers, cash for work, food for work, prevention of malnutrition and health promotion, and disaster readiness.[87,252–254] In 2012, the project benefited at least 18,242 households in four of the most food-insecure regions. Almost 20,000 schoolgirls received direct nutrition support, and 33,976 pregnant and lactating women received a monthly food ration and other health services.[252] The project has contributed to downward trends in the number of malnourished children in intervention areas.[252] Haiti has also joined the 2012 Committing to Child Survival: A Promise Renewed campaign, and pledged to reduce mortality in children under 5 years to ≤20 deaths per 1,000 live births by 2035 by reducing the leading preventable causes of child mortality, including undernutrition.[255]

1.6.2 The Case for Early Intervention

It is estimated that malnutrition will reduce global economic advancement by at least 6% percent due to direct productivity losses, and losses due to reduced schooling and poorer cognition.[256] Furthermore, the 2015 Global Nutrition Report estimates that the benefit to cost ratio of scaling up nutrition programs to be 16 to 1, and that the rate of return to be as high as 10%.[257] This implies the profound economic consequences of leaving these problems unsolved, as well as the economic benefits of implementing programs and policies to mitigate the growing rates of the dual burden of malnutrition in LMICs.

The current nutrition efforts in Haiti have shown initial successes, but the country still requires great progress before a stable nutrition environment is feasible. Haiti will continue to face challenges in the coming years as food insecurity and globalization leave the country's nutrition environment in flux. Only 5 years ago, Haiti was experiencing one of the country's worst droughts in 35 years, further exacerbated by El Niño event. Coupled with the lasting effects of the earthquake in 2010 and another only weeks ago, the devastation of Hurricane Matthew in 2016, the crop production in Haiti has greatly suffered in recent history. Price inflation of locally produced food and unfavorable socioeconomic conditions have expanded food insecurity on the island.[134] Within increasing western influence promoting the availability of highly-processed food stuffs at cheap prices, it is feasible to fathom increased consumption of these nutrient-poor foods in the near future, intensifying the consequences of the dual burden of malnutrition. For these reasons, early intervention is necessary.

Through examination of programs and policies currently implemented in other LMICs, five key elements emerge for consideration when designing intervention efforts in Haiti for the dual burden of malnutrition.[115,258–297]

- Successful programs limited project scope and used appropriate, resulting in better participation.
- Sustainable programs have built-in evaluation methods, allowing for redirection of resources and targeting when needed.
- Including community stakeholders and strategic partners during program development also aids in success.
- Partnering with large international organizations like USAID, WHO, UNICEF, and the World Bank increases the likelihood of ongoing resource support required for program sustainability.
- Early involvement of the local communities and individuals for whom the program is designed as well as local program staff, bolsters self-efficacy and empowers the

program at a grass-roots level, increasing the likelihood of participation by the intended recipients of the program as well as appropriate training and engagement of program staff.

Incorporating these elements into dual burden intervention programs and policies will enable the country to move forward towards sustainable solutions to for persistent undernutrition, emerging overweight and obesity, and an unstable food and nutrition environment.

1.6.3 Foundations for Intervention

Haiti is showing signs of nutrition transition in its early stages. While other countries have undergone dramatic changes in the last several decades, the nutrition transition in Haiti has only begun to take shape. As the evidence from other countries on the nutrition transition continuum indicates, there are apparent patterns linked to nutrition transition that will have important program and policy implications for Haiti. Of primary importance is the need for increased surveillance of nutrition transition and dual burden of malnutrition indicators. Evidence supports the need to put in place monitoring systems for national obesity rates in addition to those in place for undernutrition and micronutrient deficiency, specifically within school-age children, as the upward trends in excess body weight is in its early stages. Additionally, monitoring of NCDs is necessary in order to appropriately focus prevention efforts. Tangential to this primary necessity of monitoring is the establishment of a set definition for the dual burden of malnutrition. In previous work, underweight and stunting have both been used as a marker of undernutrition. While rates of underweight have decreased globally, rates of stunting remain high. Moving forward, the use of stunting rates as the primary marker of undernutrition will likely help treatments and interventions to maintain relevancy and efficacy.

Previous study indicates that the dual burden of malnutrition may be exacerbated by lower SES, urban residence, and migration from rural to urban living. Additionally, urban

households at greatest risk of the dual burden of malnutrition also had the lowest food diversity. Rates of overweight and obesity are also higher in urban settings than rural. Therefore, programs and policies targeting the urban poor are recommended, including supplementary nutrition programs aimed at increasing dietary diversity.

Lastly, nutrition transition is marked by a rise in DR-NCD rates, which has potential to substantially affect health care expenditures, the economic burden of lost productivity and, ultimately, the country's economy. In Haiti, early intervention to mitigate the rising rates of NCDs and the related burden on public health and medical systems will be necessary, as the country can expect increased NCD costs and outcomes similar to other transitioning countries discussed in this chapter.

In order to achieve significant reductions in both over- and undernutrition and their adverse health consequences within the next decade, Haiti will greatly benefit from the understanding of nutrition transition patterns in other transitioning countries. Rather than recycle programs and policies from other transitioning countries that have proven ineffective, using the literature to guide the implementation of targeted, time-tested, effective, and inexpensive interventions tailored to the Haitian population, will be the key to success.

1.6.4 Research Goals

To increase scientific understanding of the dual burden of malnutrition in Haiti—not just at the household level, but also at the population level for school-age adolescents—a mixed-methods needs assessment was undertaken. As Haiti's public health nutrition programs face the new complexities of nutrition transition and the dual burden of malnutrition, there is an opportunity to draw on experiences and evidence from previously transitioning countries in order to intervene early and appropriately. Application of these experiences and evidence will guide

the following research goal: to characterize the attitudes, beliefs, and behaviors, as well as the social, environmental, and health factors, associated with physical activity in Haitian school-age adolescents as related to the dual burden of malnutrition.

This project is part of long-term research agenda to a) characterize the link between the emergence of the dual burden of malnutrition and its risk factors and b) provide rationale for the early adoption of policy and program development for school-based physical activity, nutrition, and other types of assistance programming in Haiti and other LMICs, thus improving the prevention and control of malnutrition problems.

1.6.5 Specific Aims and Research Questions

Three specific aims guided this exploratory study in accomplishing the overall research goal of characterizing the attitudes, beliefs, behaviors, and related social, environmental, and health factors associated with physical activity in Haitian school-age adolescents. Physical activity behaviors will be assessed based on the WHO Recommendation (WHO REC) for physical activity in children and adolescents, which advises that children and adolescents receive ≥60 minutes of moderate or vigorous activity (MVPA) per day (defined dichotomously as *met* or *did not meet*).

- *Aim 1:* **Examine** the feasibility of self-reported and objectively-assessed methodologies for studying Haitian school-age adolescent PA behaviors, and **identify** correlates of these PA behaviors
- *Aim 2:* **Examine** interplay between nutrition and PA outcomes in Haitian adolescents within the contexts of early nutrition transition and the dual burden of malnutrition.
- *Aim 3:* **Contextualize** PA behaviors and **explore** the values, attitudes, and beliefs associated with these behaviors in Haitian school-age adolescents

In order to achieve these aims, the following research questions were posed. The specific aim(s) corresponding to each question are listed in parentheses after each question.

- *Question 1:* Will lower SES be associated with decreased odds of meeting the WHO REC?
- *Question 2:* Will barriers in both the built (e.g., roads, sidewalks, etc.) and natural environments (e.g., weather patterns, flooding, mudslides, etc.) be associated with poorer physical activity outcomes?
- *Question 3:* Will differences in gender and gender roles be associated with differences in boys and girls meeting the WHO REC?
- *Question 4:* Will increased dietary diversity be associated with increased odds of meeting the WHO REC?

Chapter 2: Paper 1- Assessing Objective Measured and Self-Reported Physical Activity in Haitian Adolescents

2.1 Background & Introduction

Physical inactivity is directly linked to health outcomes associated with progression through the nutrition transition, including increased risk for type 2 diabetes, cardiovascular disease, and premature mortality.[298] Globally, over 5 million deaths per year are related to physical inactivity, affecting countries across all income brackets.[299] While physical activity research is widely available, over half of the research studies high-income countries (HICs), leaving a gap in surveillance and intervention research for low- and middle-income countries (LMICs).[299] This is especially true for Haiti, as the country has no documented data available from the Global Observatory for Physical Activity, citing no active researchers, articles, or surveillance systems in place for physical activity.[300] Furthermore, the national Demographic and Health Surveys from the U.S. Agency for International Development do not survey or report physical activity for the country.[36–38]

Physical activity plays a large role in the burden of disease related to nutrition transition and the dual burden of malnutrition. There is mounting evidence for the early stages of both phenomena in Haiti, as country-level data shows changes in the food environment, rapid urbanization, and an overlapping prevalence of undernutrition and overweight/obesity.[36–38,91,93,134,301–305] However, a dearth of research examines the nutrition transition or the dual burden of malnutrition in the country. The majority of research addressing malnutrition in the country focuses on undernutrition; however effective surveillance and intervention programs will

need to address physical activity behaviors and their linkage to health outcomes in Haiti as the country continues to experience nutrition transition and the dual burden of malnutrition.

Evidence from dual burden research recommends increased physical activity, paired with appropriate energy and nutrient consumption, to mitigate the long-term health consequences of the dual burden.[10] For example, building lean muscle mass can benefit both extremes of malnutrition, helping undernourished and overweight/obese individuals achieve and maintain a healthy body composition. Furthermore, it has been well established that even modest exercise has been linked to the prevention of the metabolic deterioration associated with a sedentary lifestyle.[176–178] However, physical activity intervention within the context of the dual burdern must also consider proper energy supplementation, as the need for fat mass in undernourished children cannot be disregarded.[179]

Adolescence— defined by the World Health Organization (WHO) and United Nations International Children's Emergency Fund (UNICEF) as ages 10-19 years, with ages 10-15 comprising *early adolescence*– constitutes a highly vulnerable period for either repairing or further exacerbating the effects of childhood malnutrition related to the dual burden of malnutrition; adolescents are considered a nutritionally vulnerable group based on their high requirements for growth, eating patterns, lifestyles, risk-taking behaviors, and susceptibility to environmental influences.[53] This is also a significant period for cognitive growth, including the development of advanced reasoning skills, abstract reasoning, and meta-cognition.[175] Because of this brain development, adolescents experience increased autonomy with age, and thus are in the process of developing life-long preferences and habits, indicating that behavior change interventions in this group are a strategic investment in adult health and well-being.[53]

Furthermore, the adolescent growth spurt has been identified as a promising period for catch-up growth, potentially reversing previous nutritional inadequacies and mitigating the risk of adult chronic disease.[53] Thus, adolescence marks a critical opportunity for intervention in the dual burden of malnutrition. Unfortunately, data regarding adolescent health (e.g., stunting, wasting, overweight, and obesity rates; nutrition behaviors; physical activity behaviors; etc.) are unavailable for Haiti's youth.

As adolescence is marked by the school-age years, school-based interventions are a logical setting for physical activity interventions.[53,180] Additionally, the school setting represents an opportunity for sustainable intervention, as it continuously exposes adolescents to dietary and physical activity factors.[180] While a large body of evidence exists for effective school-based obesity prevention in adolescents, heretofore no such studies have been carried out in Haiti and little is available from Sub-Saharan African countries like Benin, Ghana, and Congo, countries with which Haiti shares a similar genetic ancestry and epidemiological trends.[40,180,182–185]

To date, data concerning physical activity behaviors of adolescents in Haiti are unavailable. This study sought to fill a gap in the literature by increasing scientific understanding of physical activity behaviors in Haitian adolescents, employing two different study objectives. First, this study aimed to conduct a needs assessment for physical activity intervention through two physical activity data collection methodologies, collecting both self-reported data and objectively assessed data. Second, this study aimed to collect and describe first-generation data regarding the physical activity behaviors of Haitian adolescents and potential correlates of these behaviors. As the first of its kind, this study will provide the baseline data for future intervention work related to mitigating the negative health outcomes of physical inactivity as it is related to the dual burden of malnutrition.

2.2 Methods

2.2.1 Measures

Physical Activity

Self-Report Physical Activity. Physical activity was assessed via a cross-sectional survey administered to participants by trained enumerators (five public health nurses native to Cap-Haïtien); face-to-face interview surveys were employed to allay potential barriers due to illiteracy. Adolescent participants provided self-report physical activity behavior information using questions adapted from the IPAQ long-form.[306] The IPAQ has been rigorously evaluated for validity and reliability.[306] Questions were translated from English to Haitian Creole and presented in ordinal multiple choice format (*e.g.*, Question: "During the last 7 days, on how many days did you do vigorous physical activities like running, fast bicycling, or fast swimming in your leisure time?" and "How much time did you usually spend on one of those days doing vigorous activity in your leisure time?" Possible Answers: "1. 0/ NA, 2. 0-29 minutes, 3. 30-59 minutes, 4. 60-89 minutes, 5. 90-119 minutes, 6. 120+ minutes).[306] Questions addressed three domains of physical activity: transportation related physical activity, leisure-time physical activity, and school-based physical activity (adapted from work-based physical activity questions on the IPAQ). Data was then aggregated for each domain to capture the overall time (in minutes) spent performing physical activity. The median minutes of the ordinal ranges in each domain were used to assess whether or not participants met the World Health Organization's recommendation (WHO REC) for child and adolescent physical activity of ≥60 minutes of moderate or vigorous activity (MVPA) per day (defined dichotomously as *met* or *did not meet*).[307]

Objective Physical Activity. Physical activity was also assessed in a subset of survey participants via an accelerometry study to capture objective data including duration and intensity of physical activity. The subsample was randomly selected from the larger pool of survey participants. The subsample was provided accelerometer belts with ActiGraph GT1M activity monitors, worn throughout the school week, except while sleeping or bathing. Participants with at least 5 days of a minimum of 8 hours of daily valid wear time were included in the analysis; valid wear time was assessed via visual inspection.[308] Data were collected in 15-second epochs, then collapsed into 60-second epochs. Using counts per minute (cpm) divide by wear time—a standard measure of total physical activity used in analyses of accelerometry data— levels of activity were identified.[309] Freedson and colleagues calibrated accelerometer output for children and adolescents, quantifying the following levels of physical activity: light physical activity was defined as 150-499 cpm, moderate physical activity as 500-3999 cpm, and vigorous physical activity as 4000-7599 cpm.[225] Total minutes of MVPA were then summed to evaluate whether or not participants met the WHO REC (again defined dichotomously as met or did not meet).[307]

Overweight Obesity Status and Thinness Status

Adolescent and caregiver height and weight were assessed by study enumerators at the time of survey completion. Weight was measured to the nearest 0.1 kg using a Seca model 874 (digital) scale (440 lb ×0·1 lb resolution (~200 kg×~45 g resolution)). Height was measured to the nearest 1mm using the ShorrBoard measuring board. For all participant's height and weight, two independent measures were taken, with a third measure taken if the difference between the first measures was outside the acceptable range. The averages of the height and weight measures were used to calculate body mass index (BMI). Adolescent BMI-for-age z-scores (BAZ) were generated using WHO's AnthroPlus Software, which is a tool for the global application of the

WHO Reference 2007 for 5-19 years to monitor the growth of school-age children and adolescents. Adolescent overweight was operationalized as BAZ >1 and includes obese adolescents; wasting was operationalized as BAZ<-2.

Sociodemographic Variables

Caregivers reported socioeconomic (SES) and demographic information via questions adapted from surveys previously administered in this population.[32,181,310] Caregiver-specific variables included age, occupation, and education. Occupations were reported and aggregated into five categories: *skilled trades*, *service trades*, *market vendors*, *other*, and *not employed*. Caregiver education was classified as *no education*, *primary school*, and *secondary school and beyond*.

Socioeconomic variables included number of individuals living in the household, total monthly household income (*$Haitian 100-500*, *$Haitian 501-800*, *$Haitian 801-1000*, *$Haitian 1001+*, or *don't know*), household receipt of remittances (*yes* or *no*), number of rooms in the house, main floor material of the home (*concrete/masonry*, *earth/sand/rock*, or *ceramic/mosaic tile*), main roof material of the home (*aluminum/tin* or *concrete/masonry*), frequency of household access to electricity (*sometimes*, *always*, or *never*), and household access to a flush toilet. Ownership of common assets were reported for personal property (*home* and *land* ownership), livestock (*poultry*, *goats/pigs*, *mules*, *cows*, and *horses*), technological items (*cell phones*, *televisions*, and *radios*), home amenities (*refrigerator*, *stove*, *generator*, *invertor/battery*, and *wheelbarrow*), and transportation methods (*car/truck*, *motorcycle/motorbike*, and *bicycle*).

2.2.2 Sampling, Recruitment, Consent, & Participant Eligibility

A convenience sample of adolescent students and their caregivers were recruited from one public and one private elementary school in Cap-Haïtien, the second largest city in Haiti.

The city is a low-lying, densely populated urban area. During the rainy season, it is vulnerable to flooding due to the topography and lack of waste and drain-water infrastructure. Much of the housing is of poor quality, unfinished and lacking in sanitation, water and electricity. The two schools from which participants were recruited were selected based on a previously-expressed interest in research participation and their location within this urban, poor geography.

Study coordinators contacted school administration for permission to conduct research on school grounds. School administrators distributed an informational flyer regarding the study to parents and caregivers of students in the desired age-range; 189 individuals interested in participation self-selected their attendance at two different informational meetings (one at each school) held to describe the study components. Eligibility for study participation was determined at the meeting. Participants were screened for eligibility based on the following criteria: caregiver interest and consent; aged 10-15 years; good health (no fever, congenital health condition, or helminth infection); and registration in school for the 2016–2017 academic year. Written informed consent was obtained from parents or non-parent caregivers of the adolescents in French and Creole at the time of survey completion, and adult participants were paid 200 Haitian Gourdes (~$3.15 USD) for their time and travel expenses. Verbal assent was obtained from adolescents at the time of survey completion, and they were compensated for their participation with a small bundle of school supplies.

2.2.3 Data Analysis

All analyses were conducted using IBM SPSS 25 statistical software with a significance threshold of p=.10. Because this study was designed as a first-generation needs assessment with a smaller sample size, alpha was set at 10% in order to explore preliminary patterns associated with physical activity behaviors.

Objectively Assessed Physical Activity

To model potential correlates of achieving the dichotomous WHO REC variable based on accelerometry data, logistic regression was used. Possible correlates for meeting the WHO REC were assessed individually for significance, and then loaded into a final logistic regression model of meeting the WHO REC. The final model of objectively assessed activity data included the constant, adolescent age, adolescent gender, caregiver occupation, and household access to a flush toilet.

Self-Report Physical Activity

To model potential correlates of achieving the dichotomous WHO REC variable, logistic regression was used to assess each domain (*i.e.*, school-based, transportation-related, or leisure-time physical activity) of self-report physical activity behaviors. Possible correlates for meeting the WHO REC were assessed individually for significance relative to each domain. If a statistically significant association was detected, then variables were loaded into a logistic regression model of meeting the WHO REC. For the domain of school-based physical activity, the final model of meeting the WHO REC included the constant, adolescent age, adolescent gender, caregiver occupation, and household ownership of personal property (*i.e.*, home and land ownership). The final model of meeting the WHO REC in the transportation-related activity domain included the constant, adolescent age, adolescent gender, caregiver occupation, total number living in the household, total monthly household income, total number of rooms in the home, and household ownership of transportation methods. For the leisure-time activity domain, the final model of meeting the WHO REC included the constant adolescent age, adolescent gender, caregiver gender, caregiver occupation, and total number of rooms in the house.

2.3 Results

2.3.1 Participant Characteristics

After recruitment, 153 adolescent-caregiver dyads were screened for participation. A total of 100 adolescent students were identified for participation in the self-report survey. For the accelerometry study, a subset of 80 students were selected for participation. However, due to accelerometer malfunction, noncompliance, or invalid wear time, a total of 55 students' data was ultimately assessed for meeting the WHO REC. The final adolescent participant pool for the surveys was predominantly female (68%), younger (62% aged 10-12), and of healthy body composition (85% normal BAZ).

2.3.2 Objectively Assessed Physical Activity

Differences in participant characteristics between those meeting the WHO REC and those that did not are reported in Table 1. Significant associations were found between meeting the WHO REC for physical activity and adolescent age, adolescent gender (male reference group), caregiver occupation (working in the marketplace reference group), and having a flush toilet in the home (See Table 2.1). Meeting the WHO REC was positively associated with adolescent age, indicating older adolescents were more likely to experience adequate physical activity (b= 0.54, Wald $\chi^2(1)$= 0.89, p= 0.05). In the final model of meeting the WHO REC, age did not retain significance. A significant association between adolescent gender and the WHO REC indicates males had a greater likelihood of achieving recommended physical activity levels as compared to females, as only 18.2% of females met the recommendation, but 95.5% of males did (b= 4.55,

Table 2.1. *Differences in participant characteristics for meeting the WHO REC in adolescents using objective accelerometry data (n= 55)*

	Did not meet WHO REC (n= 28)		Met WHO REC (n= 27)		
	Mean or %	SD	Mean or %	SD	*p* Value
Child Characteristics					
Age					0.05
10-12 (%)	71.4	-	59.3	-	
13-15 (%)	28.6	-	40.7	-	
Gender					
Female (%)	96.4	-	22.2	-	0.00
Male (%)	3.6		77.8		
Overweight/Obese (%)	10.7	-	7.4	-	1.00
Thinness (%)	7.1		3.7	-	1.00
School Transportation Method					0.16
Walks	78.6		92.6		
Motor vehicle (all types)	21.4		7.4		
Caregiver Characteristics					
Age					0.28
<40	57.1	-	42.3	-	
≥40	42.9	-	57.7	-	
Caregiver Female (%)	82.1	-	85.2	-	0.76
Overweight/Obese (%)	57.1	-	66.7	-	0.47
Education					0.60
No Education (%)	17.9	-	22.2	-	
Primary School (%)	42.9	-	44.4	-	
Secondary School & Beyond (%)	39.2	-	33.4	-	
Occupation					0.02
Skilled (%)	14.3	-	3.7	-	
Service (%)	14.3	-	0.0	-	
Market/Trade (%)	35.7	-	74.1	-	
Other (%)	3.6	-	7.4	-	
Not Employed (%)	32.1	-	14.8	-	
Household Characteristics					
No. Members (Mean and SD)	5.75	2.271	5.85	2.088	0.86
Household Income					0.77
$Haitian 100-500 (%)	28.6	-	29.7	-	
$Haitian 501-800 (%)	10.7	-	22.2	-	
$Haitian 801-1000 (%)	25	-	14.8	-	
$Haitian 1001+ (%)	28.6	-	33.3	-	
Don't Know (%)	7.1	-	0.0	-	
Remittances (%)	39.3	-	33.3	-	0.65
No. Rooms (Mean and SD)	2.71	1.536	2.58	1.677	0.75
Floor Material					0.92
Concrete/ Masonry (%)	85.7	-	85.2	-	
Earth/ Sand/ Rock (%)	10.7	-	14.8	-	
Ceramic/ Mosaic	3.6	-	0.0	-	
Roof Material					0.65
Aluminum / Tin (%)	60.7	-	66.7	-	
Concrete/ Masonry (%)	39.3	-	33.3	-	
Electricity					0.21
Always (%)	28.6	-	14.8	-	
Sometimes (%)	42.8	-	66.7	-	
Never (%)	28.6	-	18.5	-	
Flush Toilet (%)	32.1	-	7.4	-	0.03
Ownership of Assets					
Personal Property					0.45
Home (%)	53.6	-	51.9	-	
Land (%)	17.9	-	29.6	-	
Livestock					0.84
Poultry (%)	14.3	-	22.2	-	
Goats/ Pigs (%)	10.7	-	3.7	-	
Mule (%)	0.0	-	3.7	-	
Cows (%)	10.7	-	7.4	-	
Horse (%)	0.0	-	0.0	-	
Technology					0.4
Cell Phone (%)	85.7	-	66.7	-	
Television (%)	57.1	-	55.6	-	
Radio (%)	64.3	-	55.6	-	
Amenities					0.86
Refrigerator (%)	17.9	-	7.4	-	
Stove (%)	17.9	-	14.8	-	
Generator (%)	0.0	-	7.4	-	
Inverter/ Battery (%)	0.0	-	0.0	-	
Wheelbarrow (%)	10.7	-	14.8	-	
Transportation					0.79
Car/ Truck (%)	7.1	-	0.0	-	
Motorcycle/ Motorbike (%)	10.7	-	3.7	-	
Bicycle (%)	3.6	-	14.8	-	

Wald $\chi^2(1)= 16.53$, $p= 0.00$). The significance of the associated was maintained in the final model of meeting the WHO REC (see Table 2.2). Caregivers working in the market trading and selling increased the likelihood of their adolescents meeting the WHO REC ($b= 1.50$, Wald $\chi^2(1)= 4.43$, $p= 0.04$), however this association did not remain significant in the model. Having a flush toilet in the home decreased the likelihood of adolescents achieving the WHO REC ($b= -1.78$, Wald $\chi^2(1)= 4.50$, $p= 0.03$), but also did not remain significant in the model. The final model of meeting the WHO REC satisfied the convergence criteria and was significant (likelihood ratio (df=7)= 31.24, $p= 0.00$). The Hosmer and Lemeshow goodness-of-fit statistic (H-L (df= 6, n= 55)= 3.71, $p= 0.72$) and the Nagelkerke R^2 ($R^2= 0.75$) indicated acceptable quality of the model.

Table 2.2. *Logistic regression model* for correlates of meeting the WHO REC using objective accelerometry data (n= 55)*

Model Parameter	OR	ADJ OR‡	*p*	95 % CI
Adolescent Age	1.06	3.24	0.24	0.46, 22.60
Adolescent Gender†	10.50	12.54	0.00	9.39, 15.5
Caregiver Occupation in the Market	5.14	4.04	0.14	0.64, 25.68
Household Access to Flush Toilet	0.17	0.08	0.19	0.42, 80.52
Constant		0.00	0.02	

Notes. *The overall model satisfies convergence criteria and is significant (likelihood ratio (df=7)= 31.24, $p= 0.00$). The Hosmer and Lemeshow goodness-of-fit statistic (H-L (df= 6, n= 55)= 3.71, $p= 0.72$) and the Nagelkerke R^2 ($R^2= 0.75$) are acceptable.
†Female reference group.
‡Adjusted for all other model parameters listed in the table.

2.3.3 Self-Reported Physical Activity

School-Based Activity Domain

Logistics regression analysis of school-related physical activity showed a significant relationship between meeting the WHO REC and adolescent age, adolescent gender, caregiver occupation, and ownership of personal property (*i.e.*, home and land ownership). The association between adolescent age and meeting the WHO REC indicated that likelihood of meeting the WHO REC increased with age ($b= 0.62$, Wald $\chi^2(1)= 1.50$, $p= 0.02$). The significant association between adolescent gender and the WHO REC showed that males had increased likelihood of

meeting the WHO REC relative to their female counterparts (*b*= 0.44, Wald $\chi^2(1)$= 0.79, *p*= 0.05). Adolescents of caregivers that worked in the market selling and trading had an increased likelihood of meeting the WHO REC relative to adolescents whose caregivers had other occupations (*b*= 0.30, Wald $\chi^2(1)$= 0.36, *p*= 0.06). And adolescents whose parents or caregivers owned their home or land property had a decreased likelihood of meeting the WHO REC (*b*= -0.88, Wald $\chi^2(1)$= 2.97, *p*= 0.09).

In the final model of meeting the WHO REC under the school domain, the associations between adolescent age, adolescent gender, caregiver occupation, and personal property ownership all retained significance and direction (see Table 2.3). Older adolescents, males, and adolescents whose caregivers worked in the market all had increased odds of achieving the WHO REC. Household ownership of the home or land property was associated with decreased odds of achieving the WHO REC. The model satisfied the convergence criteria and was significant (likelihood ratio (df=8)= 93.79, *p*= 0.02). The Hosmer and Lemeshow goodness-of-fit statistic (H-L (df= 6, n= 100)= 7.52, *p*= 0.38) and the Nagelkerke R^2 (R^2= 0.30) indicated acceptable quality of the model.

Table 2.3. *Logistic regression model* for correlates of meeting the WHO REC in the school domain using self-report data (n= 100)*

Model Parameter	OR	ADJ OR‡	*p*	95 % CI
Adolescent Age	1.34	2.10	0.02	1.74, 5.94
Adolescent Gender†	1.56	2.07	0.02	1.69, 6.21
Caregiver Occupation in the Market	1.35	1.69	0.05	1.24, 1.95
Household Ownership of Home or Land	0.42	0.40	0.08	0.14, 1.12
Constant		0.14	0.03	

Notes. *The overall model satisfies convergence criteria and is significant (likelihood ratio (df=7)= 93.79, *p*= 0.02). The Hosmer and Lemeshow goodness-of-fit statistic (H-L (df= 6, n= 100)= 7.52, *p*= 0.38) and the Nagelkerke R^2 (R^2= 0.30) are acceptable.
†Female reference group.
‡Adjusted for all other model parameters listed in the table.

Transportation-Related Activity Domain

In examining the relationship between correlates of meeting the WHO REC through transportation-related physical activity, logistic regression analysis revealed significant

associations between meeting the WHO REC and adolescent age, adolescent gender, caregiver occupation, total number living in the household, total monthly household income, total numbers of rooms in the home, and household ownership of transportation methods. Older adolescents (b= 0.29, Wald $\chi^2(1)$= 2.36, p= 0.06), males (b= 0.49, Wald $\chi^2(1)$= 0.78, p= 0.04), and adolescents whose caregivers worked in the market (b= 1.52, Wald $\chi^2(1)$= 5.08, p= 0.02) had an increased likelihood of meeting the WHO REC through transportation activity. As total monthly household income increased, the likelihood an adolescent would meet the WHO REC through transportation activity decreased (b= -0.64, Wald $\chi^2(1)$= 2.86, p= 0.09). Increased total number of people living in the household (b= -0.26, Wald $\chi^2(1)$= 2.84, p= 0.09) and increased number of rooms in the house (b= -0.50, Wald $\chi^2(1)$= 3.68, p= 0.06), decreased the likelihood of meeting the WHO REC through transportation activity. Analysis of household ownership of transportation methods, overall, decreased the likelihood and an adolescents transportation related activity meeting the WHO REC (b= -0.06, Wald $\chi^2(1)$= 2.01, p= 0.09). However, analysis of the individual transportation methods revealed a divergent relationship. Ownership of a car/truck (b= -1.63, Wald $\chi^2(1)$= 1.29, p= 0.06) or motorcycle/motorbike (b= -0.54, Wald $\chi^2(1)$= 0.24, p= 0.06) decreased the likelihood of transportation activity meeting the WHO REC. Ownership of a bicycle had a small, positive influence on the likelihood of transportation activity meeting the WHO REC (b= 0.39, Wald $\chi^2(1)$= 0.12, p= 0.07).

The final model of transportation-related activity meeting the WHO REC satisfied the convergence criteria and was significant (likelihood ratio (df=10)= 71.92, p= 0.01). The Hosmer and Lemeshow goodness-of-fit statistic (H-L (df= 9, n= 100)= 8.29, p= 0.41) and the Nagelkerke R^2 (R^2= 0.29) indicated acceptable quality of the model. Adolescent age, adolescent gender, caregiver occupation in the marketplace, total number living in the household, total number of

rooms in the home, and household ownership of transportation methods all retained significance and direction in the model (see Table 2.4). Total monthly household income did not remain significant, but the direction of the association with the WHO REC retained direction.

Table 2.4. *Logistic regression model* for correlates of meeting the WHO REC in the transportation domain using self-report data (n= 100)*

Model Parameter	OR	ADJ OR‡	*p*	95 % CI
Adolescent Age	1.33	1.90	0.03	1.57, 6.33
Adolescent Gender†	1.62	2.97	0.02	2.28, 4.37
Caregiver Occupation in the Market	4.56	5.74	0.02	1.35, 24.53
Total Number Household Members	0.77	0.71	0.07	0.48, 1.03
Total Monthly Household Income	0.90	0.92	0.13	0.82, 4.53
Total Number Rooms in Home	0.61	0.57	0.07	0.31, 1.05
Household Ownership of Transportation Methods	0.65	0.94	0.06	0.31, 6.75
Constant		0.12	0.21	

Notes. *The overall model satisfies convergence criteria and is significant (likelihood ratio (df=10)= 71.92, p= 0.01). The Hosmer and Lemeshow goodness-of-fit statistic (H-L (df= 9, n= 100)= 8.29, p= 0.41) and the Nagelkerke R^2 (R^2= 0.29) are acceptable.
†Female reference group.
‡Adjusted for all other model parameters listed in the table.

Leisure-Time Activity Domain

Logistic regression analysis revealed that adolescent age, adolescent gender, caregiver gender, caregiver occupation, and total number of rooms in the home were significantly associated with leisure-time activity meeting the WHO REC. Older adolescents (b= 0.40, Wald $\chi^2(1)$= 0.66, p= 0.06), males(b= 1.50, Wald $\chi^2(1)$= 8.74, p= 0.00), and adolescents whose caregivers worked in the marketplace (b= 1.56, Wald $\chi^2(1)$= 6.78, p= 0.01) all had increased odds of meeting the WHO REC through leisure-time activity. Adolescents whose primary caregiver was male had decreased odds of having leisure-time activity meet the WHO REC (b= -1.77, Wald $\chi^2(1)$= 2.78, p= 0.10). As the number of rooms in the home increased, the likelihood of an adolescent's leisure-time activity meeting the WHO REC decreased (b= -0.51, Wald $\chi^2(1)$= 4.57, p= 0.03).

The final model of leisure-time activity meeting the WHO REC satisfied the convergence criteria and was significant (likelihood ratio (df=8)= 83.37, p= 0.00). The Hosmer and Lemeshow goodness-of-fit statistic (H-L (df= 7, n= 100)= 6.88, p= 0.55) and the Nagelkerke R^2

(R^2= 0.28) indicated acceptable quality of the model. Adolescent age and caregiver gender were not significant in the final model (see Table 2.5). The relationships between adolescent age, caregiver occupation in the marketplace, and total number of rooms in the house and leisure-time activity meeting the WHO REC all retained significance and direction.

Table 2.5. *Logistic regression model* for correlates of meeting the WHO REC in the leisure-time domain using self-report data (n= 100)*

Model Parameter	OR	ADJ OR‡	*p*	95 % CI
Adolescent Age	1.14	2.18	0.17	0.71, 6.70
Adolescent Gender†	4.49	3.37	0.03	1.11, 10.20
Caregiver Gender	0.29	0.42	0.47	0.04, 4.37
Caregiver Occupation in the Market	4.74	3.21	0.09	0.83, 12.40
Total Number Rooms in Home	0.60	0.63	0.07	0.38, 1.05
Constant		0.19	0.33	

Notes. *The overall model satisfies convergence criteria and is significant (likelihood ratio (df=8)= 83.37, *p*= 0.00). The Hosmer and Lemeshow goodness-of-fit statistic (H-L (df= 7, n= 100)= 6.88, *p*= 0.55) and the Nagelkerke R^2 (R^2= 0.28) are acceptable.
†Female reference group.
‡Adjusted for all other model parameters listed in the table.

2.4 Discussion

Objective assessment of MVPA via accelerometry data revealed older adolescents, males, and adolescents whose caregivers worked in the market were all more likely to meet the WHO REC for adolescent physical activity. However, household access to a flush toilet decreased an adolescent's likelihood of meeting the WHO REC.

Assessment of physical activity across three domains of activity behaviors consistently showed significant associations between adolescent gender, age, and caregiver occupation in the marketplace increasing the likelihood of meeting the WHO REC. Within the school activity domain, caregiver ownership of the home or land property decreased the likelihood of meeting the WHO REC. In both the transportation and leisure-time activity domains, as the total number of rooms in the home increased, the likelihood of an adolescents' activity meeting the WHO REC within these domains decreased. Likelihood of activity meeting the WHO REC in the transportation domain was also decreased as the total number of household members increased, as total monthly household income increased, and by household ownership of a car/truck or

motorcycle/motorbike. Household ownership of a bicycle slightly increased the likelihood of transportation activity meeting the WHO REC.

2.4.1 Understanding Correlates of Physical Activity

Meeting the WHO recommendation was consistently associated with adolescent age and adolescent gender. These are commonly studied correlates of physical activity in adolescents.[113,143,144,311,312] Though the significance and direction of the associations are not consistent, females are frequently shown to experience greater physical inactivity than males.[113,143,144,311,312]. Typically, research in HICs has shown older adolescents have a lesser likelihood of positive physical activity outcomes.[313–316] This study has shown the opposite relationship to be true. Further investigation within Haiti is needed to better understand the personal and social values, beliefs, and behaviors associated with gender and age roles that are prohibiting these girls and younger adolescents from achieving appropriate physical activity outcomes

Meeting the WHO REC for physical activity was significantly associated with a caregiver's employment in the market in the objective accelerometry data and across all domains in the self-report data. This finding corresponds with the laborious nature of trading and selling in the market, as these workers carry their wares with them and actively transport themselves (*i.e.*, walk) through the streets of downtown Cap-Haïtien and the surrounding areas to sell their product. This suggests a protective effect of increased caregiver physical activity against adolescent physical inactivity. Furthermore, this finding fits within the established literature, which has recognized parent/caregiver physical activity and general familial support for adolescent physical activity to be positively associated with adolescent physical activity.[143,145,146,317] However, this protective effect is not consistent, and has yet to be fully

explored within a resource-poor setting like Haiti.[113,145,311,317] This association could also be explained by employment in the market place as a marker of low SES, which has been linked to increased transportation domain physical activity levels in other LMICs.[318,319] As motor vehicle transportation options are cost-prohibitive, active transport is chosen instead. Further investigation is required within this group to understand the mechanism by which a caregiver's employment in the market and increased physical activity positively influence the physical activity outcomes of the adolescent in Cap-Haïtien.

Access to a flush toilet in the home and household ownership of electronics emerged as negative correlates for objective assessed physical activity but was significant in the self-report domains. The lack of significance in the self-report data is likely explained by the fact that objectively assessed activity typically captures short bursts of physical activity that would otherwise be overlooked in self-reported methods. As individuals without access to a flush toilet within the home are required to travel (typically by foot) a short distance in order to use the toilet, having a flush toilet in the home would decrease the minutes spent actively transporting oneself relative to those required to travel to the restroom. The negative nature of this relationship is likely explained by a link between access to a flush toilet and SES. Access to a flush toilet in the home is rare amenity in Haiti, as only 9% of households surveyed in 2016-2017 had access to a flush toilet.[38] In this study, access to a flush toilet is likely a marker for high SES; higher SES has been linked to increased sedentary time and decreased active transport in adolescents in LMICS.[318]

The number of rooms in a home and total monthly household income are also indirect measures of SES. The inverse relationship between these variables likelihood of activity levels meeting the WHO REC is likely explained by the inverse relationship between SES and physical

activity seen in other studies. Studies in higher income settings have supported an inverse relationship between SES and physical activity, but the significance of the association has been inconsistent.[113,143,144,146] However, In LMICs, a positive association between SES and physical activity has been displayed.[113] As Haiti is in the early stages of nutrition transition, which influences and is influenced by economic transition, the relationship between SES and physical activity could very well be in flux, and not static. Further investigation is required to better understand the nature of SES and its influence on adolescent physical activity outcomes.

The findings in this study deviate from previous analyses in that it did not find a significant relationship between adolescents' physical activity and certain common correlates of physical activity. For example, caregiver BMI did not have a significant association with meeting the WHO REC. The lack of association in this study could be explained by a small sample size. Adolescent transportation method and caregiver education level also did not have significant associations with physical activity outcomes, and these results are best explained by the lack of variation in the sample; most respondents were walked to school, and most caregivers had not completed primary school or did not receive education beyond the completion of primary school. While indicators have varied significance in developed countries, their application may not be as relevant in a low-resource context in LMICs, where cultural norms around education differ.[144,317]

The inverse relationship between total number of people living in the household and meeting the WHO REC is probably best explained by the dissemination of household chore responsibility across a larger group of people. Adolescents with more siblings or more adult caregivers in the home likely have a decreased level of responsibility for completing chores in the home that would otherwise increase daily activity levels.

The association between household ownership of various household methods and likelihood of meeting the WHO REC follows a logical relationship. Household ownership of a car/truck or a motorcycle/motorbike decreased the likelihood of a child's transportation activity meeting the WHO REC; this makes sense as having motorized transportation available would decrease the likelihood of pedestrian transportation. Furthermore, household ownership of a motor vehicle is likely an indicator of high SES, which, as previously stated, has been linked to decreased active transport and increased sedentary time in adolescents in other LMICs.[318] Ownership of a bicycle slightly increased the likelihood of transportation activity meeting the WHO REC; again, this makes sense as biking is a means of active transportation. Bicycle ownership is not very common; in fact, the percentage of households owning a bicycle decreased by roughly half between 2007and 2012 (17.5% in 2006 and 8.6% in 2012).[36,37] Furthermore, there is little pedestrian space available for safe transport via bicycle.[134,320]

2.4.2 Understanding the Context of the Dual Burden

The results reported here represent first generation data to be used in describing the role of physical activity in the emergence of the dual burden of malnutrition. Using the conceptual model presented in Section 1.4.2 of Chapter 1, this data describes one part of the behavioral and biological factors that affect an adolescent's growth and development, ultimately influencing his/her health outcomes. This study operationalized physical activity-related factors as meeting the WHO REC for child and adolescent physical activity. The results of this study have highlighted the importance of age, gender, and caregiver occupation in explaining adolescent physical activity outcomes. This calls for a better understanding of the immutable and contextual factors that precede the physical activity factors in the model. Though age and gender are immutable, demographic factors, studying and describing the interplay between the Haitian

context and adolescents' demographics can guide purposeful implementation of physical activity interventions for this population. Similarly, understanding the role of caregiver occupation calls for study of the interactions between family history and structure, socio-cultural factors (specifically SES), and adolescent physical activity. Studying this interplay could call for interventions designed for the family as a whole, rather than targeting only the child. Previous research in high-income settings has shown family-based physical activity to have significant associations with positive physical activity outcomes for both children and adults, thus meriting their evaluation in this context as well.[113,144]

This study controlled for extrinsic health related factors in the screening process for participation eligibility, and thus statements about their effects cannot be made here. Furthermore, this study did not account for diet-related factors and the possible interplay between diet, physical activity, and health outcomes. The next chapter will address this component of the conceptual model, in order to better describe physical activity factors within the context of the nutrition transition.

2.4.3 Strengths and Limitations

This study has both strengths and limitations that merit addressing. The most relevant limitation is sample size. The model for physical activity provided here could change within a larger sample population, and the possibility of committing a Type II error in the model cannot be excluded. Furthermore, the small sample size limits the number of variables used in the model, thus potential over-fitting of the model may occur. The possibility of unmeasured confounding variables may influence or explain some of the observed relationships, and thus cannot be disregarded. Another limitation is the inability to measure physical activity during swimming or bathing, as these are periods of activity undocumented due to the water-sensitive

nature of the accelerometer devices. The use of median physical activity estimates in the self-report data could either overestimate of underestimate actual activity levels across the three domains. The cross-sectional design of this study limits conclusions regarding the cause-and -effect relationships, as well as the direction of the associations observed, but does provide important preliminary benchmarking data for future physical activity studies in Haitian adolescents. Heretofore, this data has been unavailable to researchers.

The sampling frame of this study limits generalizability to all of Haiti and to other LMICs. Representing only an urban poor segment of Haiti, the results described here are not applicable for rural populations in Haiti of the same socioeconomic class. However, Haiti has been experiencing rapid urbanization in the last decade; over 60% of the population lives in urban areas, an overall increase of >10% in the last ten years. Thus, examination of the urban poor will continue to be of great relevance to public health research in the country.[102,303]

A marked strength of the study is the "triangulation" of self-report surveys using the objectively assessed physical activity via accelerometers. The ability to compare correlates of physical activity across the two data collection methodologies is the first of its kind in this context, providing justification for both self-report and accelerometer assessments in future research. An additional strength is the rigorous training of study enumerators and the standardization of the protocol between both study sites; this includes the use of the same study personnel, same anthropometric equipment, and accelerometer units for the both the self-report face-to-face assessments as well as the objective assessment. Furthermore, all data management and analysis were centrally conducted at a central location, which assured consistency in data handling and interpretation.

2.4.4 Conclusions

The findings in the present study are generally consistent with the current body of literature, with deviations likely due to the evaluation of a different context (*i.e.*, a resource-poor urban environment in an LMIC). Meeting the WHO recommendation for physical activity in adolescents was consistently related to adolescent sex and adolescent age. While this study cannot make causal statements, it does suggest that future research is necessary to further evaluate physical activity in Haitian adolescents—its predictors, cultural norms, and protective benefits are still largely unknown in this context. As such, further evaluation should be conducted within the lens of this study's findings, as they suggest that policy and environmental interventions are best applied to younger, female adolescents in Haiti.

Chapter 3: Paper 2- Examining the Associations Between Diet and Physical Activity in Haitian Adolescents

3.1 Background & Introduction

Rapid changes in the food environment and physical activity patterns have resulted in increasing prevalence of overweight and obesity in low and middle-income countries (LMICs)—such as seen in Haiti.[14,37,38] The nutrition transition and physical activity transitions in Haiti have resulted in a dual burden of malnutrition, as undernutrition persists as a public health problem in the midst of the emergence of overweight and obesity across all age stratifications.[32,33,36–38] Various factors contribute to the dual burden of malnutrition—most notably: rapid urbanization; increased physical inactivity; and changing dietary patterns marked by shifts from plant-based diets to poor-quality, energy-dense, but cheap and affordable foods.[9,14,16] Urbanization fuels physical inactivity and changing diets. Individuals tend to shift from active, agrarian lifestyles to more sedentary behaviors; exposure to processed foods high in sugar, fat, and salt are increased; and the protective effects of family connectedness and subsistence agriculture are diminished.[9,16,321]

Limited physical activity and a poor nutrition environment will have serious health consequences for Haiti's youth. Adolescence marks a critical period of nutritional vulnerability as it is a time with high requirements for growth.[53] Adequate nutrition in adolescence is required for the appropriate growth and development to be physically active. Furthermore, the adolescent growth spurt has been identified as a promising period for catch-up growth, potentially reversing previous nutritional insults and mitigating the risk of adult chronic disease.[53] Thus, adolescence

marks a critical opportunity for intervention in the dual burden of malnutrition. Unfortunately, data regarding adolescent health (e.g., stunting, wasting, overweight, and obesity rates; nutrition behaviors; physical activity behaviors; etc.) are unavailable for Haiti's youth.

Many nutritional factors are critical for the achievement of sufficient bone health and motor development in childhood and adolescence, without which barriers to physical activity present over the life span.[322] Malnutrition leads to stunting, rickets, and osteomalacia, osteoporosis, bone fractures, osteopenia, anemia, and other syndromes related to vitamin and mineral deficiencies.[322,323] Early childhood malnutrition related to stunting and growth delay is associated with delayed motor development, which in turn delays a child's actions and physical movements independent of caregivers.[65,324–329] Additionally, mastery of motor skills in childhood has been identified as potential predictor of adolescent motor skill mastery and adolescent physical activity.[330–332] Nutrition interventions for motor development in early childhood and physical activity interventions for motor skill mastery in adolescence may have important impacts in adolescent physical activity outcomes and overall adolescent health, especially as regular weight-bearing physical activity in adolescence promotes the development and maintenance of a healthy musculoskeletal system and body composition.[322–324,330,331]

Understanding the interplay of the current food environment, diet, and adolescent physical activity behaviors in Cap-Haïtien is a necessary first step in mitigating increasing prevalence of the dual burden. Though evidence exists for these risk factors, a paucity of information concerning the relationship between nutrition and physical activity behaviors persists, especially in adolescents or in LMICs.[311,333–335] Studies in other settings have shown that dietary and physical activity behaviors show clustering patterns in individuals, and risk of insufficient physical activity in adolescents clustered with not meeting dietary guidelines, and

more prominently so in girls than in boys.[311,333–335] A prior study of adolescents from two primary schools in Cap-Haïtien showed associations between age, sex, and physical activity outcomes (see Chapter 2); it suggested both younger and female adolescents were less likely to spend time performing enough moderate or vigorous physical activity (MVPA) to meet the World Health Organization's recommendation (WHO REC) for physical activity in children and adolescents (≥60 minutes of MVPA per day).[307] This study expands upon the previous research, with special attention given to the context of the nutrition transition and physical activity transition. Here, the association between dietary patterns and physical activity outcomes in Haitian adolescents is explored, examining the whether or not an association between increased dietary diversity and increased likelihood of meeting the WHO REC exists.

3.2 Methods

3.2.1 Design and Study Procedures

The sample was comprised of students participating in needs assessment study of physical activity behaviors; the design, measures, and study procedures have been previously described in detail (see Chapter 2). Briefly, the study was a cross-sectional survey of adolescents recruited from two urban, poor primary schools in Cap-Haïtien; students provided self-report physical activity using questions from adapted from the IPAQ long-form questionnaire and self-reported nutrition behaviors using a 24-hour food recall survey designed for and previously administered in this population.[32,181,306] Adolescent height and weight were assessed by trained enumerators.

Following survey completion, a subset of adolescent participants was randomly selected for an accelerometry study. This study aimed to capture objective physical activity data including duration and intensity of physical activity and assess total daily minutes of MVPA. The

subsample was provided accelerometer belts, worn for throughout the school week except while sleeping or bathing.

3.2.2 Nutrition Measures

Dietary Diversity and Diet Patterns

Children's dietary intake was assessed using questions from the 24-hour FFQ—a tool adapted from the Demographic and Health Surveys Program used to measure dietary intake in LMICs.[336] Adapting the questions for a Haitian context was based on formative research to reflect the dietary patterns and foods commonly consumed within this population. Children were asked how many times in the previous 24 hours they had eaten the following 17 items: cassava (a flatbread made from the manioc root); white or wheat bread; cereals, porridge, or other grains; roots and tubers; beans and other legumes; eggs; milk; fermented milk or yogurt; cheese and other dairy products; poultry; other meat (including beef, goat, sheep, or pork); fish and shellfish; fruits; vegetables; oils, butter and other fats; crackers; and cookies.

Several approaches were used to characterize dietary diversity. First, all food items were aggregated to create a dietary diversity score using USAID guidelines (possible score 0-17).[337,338] Finally, *a posteriori* analysis of dietary quality was conducted via principal components analysis (PCA), grouping food items based on clustering of intake, thus deriving dietary patterns.[339] Six dietary patterns (PCA 6-factor) were extracted based on the eigen value greater than 1 cut-off point, and two dietary patterns (PCA 2-factor) were extracted using the scree test. Within the software, the patterns were rotated using the non-orthogonal direct oblimin rotation method, which loads the individual food items maximally on to one dietary pattern while allowing for correlations between food factors; this provided the best representation of diet

patterns as allowing for correlations between food items would show foods commonly consumed together.

Eating Habits

To characterize other aspects of dietary practices, children were asked how often they eat breakfast, bring a snack/meal to school, or buy a snack/meal from the vendors just outside school grounds (each assessed as *ever* performing the behavior, or *never* performing the behavior). Adolescents were also asked whether or not they had any micronutrient supplementation in the previous six months, addressing common vitamins and minerals used within the target population. Finally, caregivers reported monthly household expenditures (*$Haitian 0-20, $Haitian 21-40, $Haitian 41-60, $Haitian 61+*).

3.2.3 Data Analysis

All analyses were conducted using IBM SPSS 25 statistical software with a significance threshold of p=.10. Because this study was designed as a first-generation needs assessment with a smaller sample size, alpha was set to10% in order to explore preliminary trends associated with physical activity behaviors.

Differences in dietary behaviors between adolescents meeting the WHO REC and those that did not were examined using logistic regression. Logistic regression was also used to assess the relationship between the PCA 6-factor pattern and the WHO REC, as well as the PCA 2-factor pattern and the WHO REC. Given a significant relationship between any of the diet variables and the WHO REC, independent models were then built to model the relationship between diet/nutrition variables and physical activity outcomes. Previous correlates of physical activity identified in Chapter 2 were used in the models as described below.

Objective Physical Activity

To model potential correlates of achieving the dichotomous WHO REC variable using the objective accelerometry data, logistic regression was used. Possible correlates for meeting the WHO REC were assessed individually for significance, and then loaded into a final logistic regression model of meeting the WHO REC. The final model of objectively assessed activity data included the constant, adolescent age, adolescent gender, caregiver occupation, household access to a flush toilet, and dietary diversity score.

Self-Report Physical Activity

Potential correlates of achieving the dichotomous WHO REC variable in self-reported physical activity behaviors were identified using logistic regression for each activity domain (*i.e.*, school-based activity, transportation-related activity, or leisure-time physical activity). Possible correlates for meeting the WHO REC were assessed individually for significance relative to each domain. If a statistically significant association was detected, variables were then loaded into a logistic regression model of meeting the WHO REC. For the domain of school-based physical activity, the final model of meeting the WHO REC included the constant, adolescent age, adolescent gender, caregiver occupation, household ownership of personal property (*i.e.*, home and land ownership), and dietary diversity score. The final model of meeting the WHO REC in the transportation-related activity domain included the constant, adolescent age, adolescent gender, caregiver occupation, total number living in the household, total monthly household income, total number of rooms in the home, household ownership of transportation methods, and dietary diversity score. For the leisure-time activity domain, the final model of meeting the WHO REC included the constant adolescent age, adolescent gender, caregiver

gender, caregiver occupation, total number of rooms in the house, dietary diversity score, and adolescent bringing a snack or meal to school.

3.3 Results

3.3.1 Participant Characteristics

Differences in participant characteristics between adolescents meeting the WHO REC and those that did not have been previously reported (see Chapter 2, Table 1). After recruitment, 153 adolescent-caregiver dyads were screened for participation, with a final sample size of 100 adolescents. The final adolescent participant pool was 68% female, 62% ages 10-12 years, 10% overweight/obese (BAZ $\geq$ 1), and 5% wasting (BAZ<-2). A total of 55 students participated in the accelerometry study.

Dietary diversity score was significantly associated with meeting the WHO REC in the objective data and in all three domains of the self-report data. Neither *a posteriori* dietary pattern (6-factor PCA or 2-factor PCA) were significantly associated with physical activity outcomes, and thus were excluded from modelling physical activity behavior. Bivariate analyses of demographic variables and their associations with the WHO REC in the objective data and across the three self-report domains have already been reported (see Chapter 2).

3.3.2 Associations between Diet and Physical Activity

Objective Physical Activity

Differences in diet and nutrition variables between those whose objective activity met the WHO REC and those whose did not are reported in Table 3.1. The final logistic regression model of meeting the WHO REC using objective physical activity data satisfied convergence criteria and was significant (likelihood ratio (df= 8)= 18.71, p= 0.00). The Hosmer and Lemeshow goodness-

Table 3.1. *Differences in participant characteristics for meeting the WHO REC in adolescents using objective accelerometry data (n= 55)*

	Did not meet WHO REC (n= 28)		Met WHO REC (n= 27)		
	Mean or %	SD	Mean or %	SD	*p* Value
Nutrition Characteristics					
Dietary Diversity Score (Mean and SD)	5.1	1.96	6.9	2.58	0.01
Eats Breakfast					0.97
Ever (%)	92.9	-	92.6	-	
Never (%)	7.1	-	7.4	-	
Brings a Snack or Meal					0.87
Ever (%)	42.9	-	40.7	-	
Never (%)	57.1	-	59.3	-	
Buys a Snack or Meal					0.65
Ever (%)	89.3	-	85.2	-	
Never (%)	10.7	-	14.8	-	
Takes Vitamins (%)	14.3		11.1		0.73
Monthly Food Expenditures					0.90
$Haitian 0-20 (%)	39.3	-	37.1	-	
$Haitian 21-40 (%)	21.4	-	18.5	-	
$Haitian 41-60 (%)	14.3	-	22.2	-	
$Haitian 61+ (%)	25.0	-	22.2	-	

of-fit statistic (H-L (df= 5, n=55)= 1.14, p= 0.99) and the Nagelkerke R^2 (R^2= 0.87) indicated high model quality. Dietary diversity score was significantly associated with the adolescent meeting the WHO REC (see Table 3.2). The significance of the DDS suggests that increased dietary diversity increased the likelihood of the adolescent meeting the WHO REC. Adolescent age and adolescent sex were significantly associated with meeting the WHO REC. Older adolescents were more likely to meet the WHO REC than younger adolescents. Males were exceedingly more likely to meet the WHO REC than their female counterparts. Caregiver occupation in the market did not retain significance in the model, though the direction of the association remained unchanged. Household access to a flush toilet significantly decreased the odds of an adolescent's objective physical activity data meeting the WHO REC. All other

Table 3.2. *Logistic regression model* for correlates of meeting the WHO REC using objective accelerometry data (n= 55)*

Model Parameter	OR	ADJ OR‡	*p*	95 % CI
Adolescent Age	1.06	4.17	0.03	1.31, 55.79
Adolescent Gender†	10.50	48.19	0.00	22.16, 77.92
Caregiver Occupation in the Market	5.14	5.43	0.18	0.46, 64.45
Household Access to a Flush Toilet	0.17	0.03	0.03	0.00, 0.66
Dietary Diversity Score	1.41	4.48	0.03	1.12 16.76
Constant		0.00	0.02	

Notes. *The overall model satisfies convergence criteria and is significant (likelihood ratio (df= 8)= 18.71, p= 0.00). The Hosmer and Lemeshow goodness-of-fit statistic (H-L (df= 5, n= 55)= 1.14, p= 0.99) and the Nagelkerke R^2 (R^2= 0.87) are acceptable.
†Female reference group.
‡Adjusted for all other model parameters listed in the table.

nutrition variables described in Table 1 were excluded based on lack of association with the WHO REC outcome variable.

Self-Report Physical Activity

School-Based Activity Domain. Logistics regression analysis of school-related physical activity showed a significant relationship between meeting the WHO REC and dietary diversity. Increased dietary diversity was significantly associated with increased likelihood of meeting the WHO REC (b= 0.38, Wald $\chi^2(1)$= 11.58, p= 0.00). Other nutrition and diet variables were not found to have a significant association with school-activity meeting the WHO REC, and therefore were excluded from the final model.

In the final model of meeting the WHO REC under the school domain, significant associations were found between the WHO REC and dietary diversity, adolescent age, adolescent gender (see Table 3.3). Again, adolescents with higher dietary diversity, older adolescents, and males all had increased likelihood of meeting the WHO REC. Caregiver occupation in the marketplace and home or land ownership by parents or caregivers was not found to be significant. The model satisfied the convergence criteria and was significant (likelihood ratio (df= 8)= 80.81, p= 0.00). The Hosmer and Lemeshow goodness-of-fit statistic (H-L (df= 5, n= 100)= 6.77, p= 0.56) and the Nagelkerke R^2 (R^2= 0.28) indicated acceptable quality of the model.

Table 3.3. *Logistic regression model* for correlates of meeting the WHO REC in the school domain using self-report data (n= 100)*

Model Parameter	OR	ADJ OR‡	*p*	95 % CI
Adolescent Age	1.34	2.03	0.06	0.66, 6.31
Adolescent Gender†	1.56	1.41	0.06	0.40, 4.97
Caregiver Occupation in the Market	1.35	0.46	0.20	0.14, 1.52
Household Ownership of Home or Land	0.42	0.47	0.18	0.16, 1.40
Dietary Diversity Score	1.45	1.49	0.00	1.17, 1.90
Constant		0.01	0.00	

Notes. *The overall model satisfies convergence criteria and is significant (likelihood ratio (df=8)= 80.81, p= 0.00). The Hosmer and Lemeshow goodness-of-fit statistic (H-L (df= 5, n= 100)= 6.77, p= 0.56) and the Nagelkerke R^2 (R^2= 0.28) are acceptable.
†Female reference group.
‡ Adjusted for all other model parameters listed in the table.

Transportation-Related Activity Domain

Transportation-related physical activity meeting the WHO REC was significantly associated with dietary diversity score. Adolescents with higher dietary diversity were more likely to meet the WHO REC (*b*= 0.30, Wald $\chi^2(1)$= 7.45, *p*= 0.00).

The final model of transportation-related activity meeting the WHO REC satisfied the convergence criteria and was significant (likelihood ratio (df=10)= 68.04 *p*= 0.00). The Hosmer and Lemeshow goodness-of-fit statistic (H-L (df= 8, n= 100)= 9.70, *p*= 0.29) and the Nagelkerke R^2 (R^2= 0.34) indicated acceptable quality of the model. Increased dietary diversity, older adolescent age, male adolescent gender, caregiver occupation in the marketplace, all held a significant, positive association with transportation activity meeting the WHO REC (see Table 3.4). As the total number living in the household increased, this had a significant, negative association with transport activity meeting the WHO REC. Total monthly household income, total number of rooms in the home, and household ownership of transportation methods were not found to have a significant association with the WHO REC.

Table 3.4. *Logistic regression model* for correlates of meeting the WHO REC in the transportation domain using self-report data (n= 100)*

Model Parameter	OR	ADJ OR‡	*p*	95 % CI
Adolescent Age	1.33	1.90	0.04	1.55, 6.53
Adolescent Gender†	1.62	1.22	0.04	1.22, 3.03
Caregiver Occupation in the Market	4.56	5.66	0.02	1.27, 25.20
Total Number Household Members	0.77	0.70	0.09	0.46, 1.06
Total Monthly Household Income	0.90	0.75	0.22	0.27, 4.27
Total Number Rooms in Home	0.61	0.63	0.14	0.34, 1.16
Household Ownership of Transportation Methods	0.65	0.29	0.76	0.26, 6.52
Dietary Diversity Score		1.25	0.06	0.99, 1.57
Constant		0.03	0.07	

Note. *The overall model satisfies convergence criteria and is significant (likelihood ratio (df=10)= 68.04 *p*= 0.00). The Hosmer and Lemeshow goodness-of-fit statistic (H-L (df= 8, n= 100)= 9.70, *p*= 0.29) and the Nagelkerke R^2 (R^2= 0.34) are acceptable.
†Female reference group.
‡ Adjusted for all other model parameters listed in the table.

Leisure-Time Activity Domain

Leisure-time activity meeting the WHO REC was significantly associated with dietary diversity and an adolescent bringing a snack or meal to school. Increased dietary diversity increased the likelihood that an adolescent's leisure-time activity would meet the WHO REC (*b*= 0.37, Wald $\chi^2(1)= 11.97$, *p*= 0.00). Additionally, adolescents that ever brought a snack or a meal to school were more likely to meet the WHO REC than those that never did (*b*= 0.81, Wald $\chi^2(1)= 2.70$, *p*= 0.10).

Table 3.5. *Logistic regression model* for correlates of meeting the WHO REC in the leisure-time domain using self-report data (n= 100)*

Model Parameter	OR	ADJ OR‡	*p*	95 % CI
Adolescent Age	1.14	2.16	0.23	0.62, 7.62
Adolescent Gender†	4.49	3.95	0.04	1.09, 14.33
Caregiver Gender	0.29	0.30	0.35	0.02, 3.68
Caregiver Occupation in the Market	4.74	2.86	0.18	0.62, 13.16
Total Number Rooms in Home	0.60	0.73	0.24	0.43, 1.24
Dietary Diversity Score	1.45	1.37	0.01	1.09, 1.74
Brings a Snack or Meal	2.25	4.17	0.03	1.18, 14.67
Constant		0.01	0.04	

Notes. *The overall model satisfies convergence criteria and is significant (likelihood ratio (df= 10)= 68.82, *p*= 0.00). The Hosmer and Lemeshow goodness-of-fit statistic (H-L (df= 8, n= 100)= 7.34, *p*= 0.50) and the Nagelkerke R^2 (R^2= 0.45) are acceptable.
†Female reference group.
‡ Adjusted for all other model parameters listed in the table.

The final model of leisure-time activity meeting the WHO REC satisfied the convergence criteria and was significant (likelihood ratio (df= 10)= 68.82, *p*= 0.00). The Hosmer and Lemeshow goodness-of-fit statistic (H-L (df= 8, n= 100)= 7.34, *p*= 0.50) and the Nagelkerke R^2 (R^2= 0.45) indicated acceptable quality of the model. Adolescent age, caregiver gender, caregiver occupation in the market, and total number of rooms in the home were not significant in the final model (see Table 3.5). Males, adolescents with higher dietary diversity scores, and adolescents that brought a snack or meal to school all had increased likelihood of their leisure-time activity meeting the WHO REC, retained significance and direction from bivariate analysis.

3.4 Discussion & Conclusions

This study is the first of its kind to examine the relationship between nutritional indicators and adolescent physical activity outcomes in a low-resource setting. Dietary diversity, adolescent age, and adolescent gender all had a significant, positive association with meeting the WHO REC across data collection methodologies and domains of activity. This study aimed to determine whether or not increased dietary diversity would be associated with increased likelihood of meeting the WHO REC, and indeed adolescents with high dietary diversity scores had increased likelihood of meeting the WHO REC in the objective data and in all three domains of their self-reported activity behaviors. Older adolescents and males were also more likely to meet the WHO REC than younger adolescents or females. Additionally, an adolescent that sometimes or always brought a snack or meal to school was more likely to meet the WHO REC in his or her leisure-time activity than those that never brought a snack or meal to school.

3.4.1 Discussion of Findings

Dietary diversity is globally recognized as an indicator of diet quality and micronutrient intake. This study posits that the mechanism by which dietary diversity influences physical activity is explained by the physiological and developmental importance of ample nutrient consumption related to bone health and motor skill mastery.[330–332,340,341] Furthermore, higher dietary diversity implies adequate energy consumption, which is required for performing MVPA.

The most commonly consumed foods were cereals, porridge, or other grains; oils, butters, and other fats; white or wheat bread; and crackers; which are affordable, calorie-dense, micronutrient-poor foods. Less than half of the sample had consumed either fruits, vegetables, or both in the previous 24 hours, which are good food sources for micronutrients. In this study, increased dietary diversity was largely attributable to consumption of animal source foods. Of

the participants with a dietary diversity score > 7, 88.5% of them had consumed more than one animal source food in the previous 24 hours. Conversely, of adolescents' with a dietary diversity score ≤ 7, only 26% had eaten more than one animal source food in the previous 24 hours. Previous research in Haitian children has shown that

The role of SES in increased dietary diversity cannot be ignored, as a higher income provides the opportunity for purchase and consumption of ample caloric energy consumption. This is important for future study of dietary diversity in countries like Haiti as they experience nutrition and physical activity transition. Increased SES has been linked to increased dietary diversity; increased dietary diversity has displayed protective effects on body composition in low-income settings, but it has also been linked to overweight and obesity in high-income settings.[342–344] Thus, future research would benefit from careful consideration of the balance of appropriate energy intake and dietary diversity, lest its protective benefits be lost through progression along the nutrition transition continuum. The role of physical activity in achieving and maintaining a healthy body composition will be important for maintaining the protective effects of dietary diversity, especially as results presented in Chapter 2 displayed a potential link between increased SES and decreased physical activity levels in adolescents, a finding that mirrors data from other LMICs.[318,319] Thus future research could also benefit from concurrent study of nutrition and physical activity within interventions aimed at the dual burden of malnutrition.

Adolescent age and sex were found to be significant in the model as well as in previous analyses (see Chapter 2). Younger adolescents and female adolescents experienced poorer physical activity outcomes, having a decreased likelihood of meeting the WHO REC for physical activity in the objective data and across the self-reported domains. Age and sex are commonly

studied predictors of physical activity in adolescents, but the significance and direction of the associations are inconsistent.[113,143,144,311,312] Regardless, females are frequently shown to experience greater physical inactivity than males, as is consistent with the findings of this study.[113,143,144,311,312] Typically, research in high-income settings has shown older adolescents have a lesser likelihood of positive physical activity outcomes.[313–316] This study has shown the opposite relationship to be true, which prompts the need for further analysis of physical activity outcomes in a low-income setting, such as in Cap-Haïtien. As Haiti is in the early stages of nutrition transition, ongoing evaluation of the appropriate balance of dietary intake with physical activity will be necessary in any future interventions, lest the protective benefits of dietary diversity be lost due to changing food environments.[342]

The positive association between bringing a snack or meal and meeting the WHO REC for physical activity is best explained by the relative quality of food prepared at home to the foods available for purchase around the school. A family of low SES may not be able to send their child to school with money for purchasing food but could perhaps afford to send the adolescent to school with a pre-prepared snack or meal. It is likely that the higher dietary and nutritional quality of foods prepared at home provides the adolescent with the adequate musculoskeletal health and energy required for MVPA, which in-turn promotes achievement of the WHO REC for physical activity in adolescents.

3.4.2 Understanding the Context of the Dual Burden

The results reported here represent first generation data to be used in describing the interplay between physical activity and diet in the emergence of the dual burden of malnutrition. Using the conceptual model presented in Section 1.4.2 of Chapter 1, this data describes the behavioral and biological factors related to diet and physical activity. This study operationalized

physical activity-related factors as meeting the WHO REC for child and adolescent physical activity and diet-related factors as the USAID dietary diversity score. The results of this study have highlighted the importance of dietary diversity in an adolescent's ability to participate in physical activity behaviors that meet the WHO REC. In the previous chapter, contextual factors related to age, gender, and SES were described. The expansion of the analysis to more fully apply the conceptual model showed these factors retained significance after the addition of diet-related factors to the analysis. This calls for a better understanding of the sociocultural context that could be affecting diet-related factors, such as feeding behaviors, feeding order, and dietary norms, and nutrition values, attitudes, beliefs, and behaviors.

The findings of this study showed a strong link between nutrition and physical activity, affirming their placement in the conceptual modeling, linking them to body composition and health outcomes. Haiti and other LMICs are experiencing rapid changes in both the nutrition and physical activity transitions. As such, future research and intervention in the dual burden could benefit from the application of this conceptual model, concurrently studying nutrition and physical activity together, their interplay, and their role in mitigating the negative health consequences of the dual burden

3.4.3 Strengths and Limitations

Small sample size and a lack of variability in the dependent variables could potentially limit detection of significant correlates of meeting the WHO REC. The model for physical activity provided here could change within a larger sample population, and the possibility of committing a Type II error in the model cannot be excluded. Furthermore, the small sample size limits the number of variables used in the model, thus potential over-fitting of the model may occur. Significant correlates commonly cited in the literature were not significant in this study,

which could possibly be attributed to the low-resource setting of this study—or could simply be limited by the small sample size for the analyses. Furthermore, the possibility of unmeasured confounding variables cannot be disregarded, as they may influence or explain some of the observed relationships analyzed here. However, the acceptable R^2 values of the models suggest that the current model adequately captures the context of and associations with adolescent physical activity in Haiti. The cross-sectional design of this study limits conclusions regarding the cause-and -effect relationships, as well as the direction of the associations observed, but does provide important preliminary benchmarking data for future physical activity studies in Haitian adolescents.

The sample methods employed in this study limits generalizability to the rest of the country and to other LMICs. The convenience sample described here represents only an urban and a poor segment of Haiti. However, as Haiti has been experiencing rapid urbanization—60.88% of the population lives in urban areas with an annual rate of change hovering around +3% and an overall increase of >10% in the last ten years—examination of the urban poor is becoming more and more relevant to public health research in the country.[102,303]

A marked strength of this study is the provision of baseline, benchmarking data for future intervention in the dual burden within Haiti. Heretofore, there has been a large gap in the available literature regarding adolescent health (e.g., stunting, wasting, overweight, and obesity rates; nutrition behaviors; physical activity behaviors; etc.) for Haiti's youth. The findings presented here can be used as preliminary data for larger studies that more rigorously and systematically explore factors related to physical activity.

An additional strength is the rigorous training of study enumerators and the standardization of the protocol between both study sites; this includes the use of the same study

personnel, same anthropometric equipment, and accelerometer units for the both the self-report face-to-face assessments as well as the objective assessment. Finally, all data management and analysis were centrally conducted to ensure consistency in data handling and interpretation.

3.4.4 Conclusions

Meeting the WHO recommendation for physical activity in adolescents was consistently associated with dietary diversity, adolescent age, and adolescent gender. The findings in the present study are consistent with the current body of literature, with deviations possibly attributable to the evaluation of a different context (*i.e.*, a resource-poor urban environment in an LMIC). Future analyses with a larger sample size are necessary to further evaluate physical activity in Haitian adolescents for purposes of identifying predictive associations. Moreover, future study of adolescent physical activity behaviors should explore the sociocultural norms related to age and gender roles at school and at home, body composition, feeding order and feeding behaviors, and nutrition and health attitudes and beliefs.

Though this study cannot make assertions about causal links, application of the findings of this study to future policy and environmental interventions for adolescent physical activity suggest consideration of incorporating dietary diversity interventions for increasing consumption of animal source foods. As also suggested by the results presented here and in Chapter 2, such interventions should also consider focusing on younger, female adolescents in Haiti, as this group consistently experiences poorer physical activity outcomes relative to other groups. This study suggests the association between dietary diversity and physical activity to be robust, and thus balancing appropriate diet and physical activity could be important for the health outcomes of Haitian adolescents in the midst of the nutrition transition.

Chapter 4: Paper 3- A Qualitative Understanding of Haitian Adolescent Health, Nutrition, and Physical Activity

4.1 Background & Introduction

The nutrition and physical activity transitions are underway in Haiti (See Chapter 1). Though undernutrition persists within Haiti, national obesity rates have increased in the last decade, signaling the onset of the dual burden of malnutrition.[36–38] However, Haiti is in the earlier stages of nutrition an physical activity transition, representing a unique opportunity for timely intervention and prevention of negative health outcomes.

Previous qualitative studies have proven useful in developing programs and interventions for other public health and well-being research in the Haitian context. Studies related to disaster recovery post-earthquake, economic lending, coping with HIV, mobile medicine, and nutrition promotion have benefited from qualitative investigation.[345–353] Applying qualitative methodologies to physical activity research in Haiti is a necessary step in identifying potential intervention points for mitigating the negative public health outcomes associated with the dual burden of malnutrition.

Interventions aimed at school-age adolescents represent a critical opportunity for early prevention of the public health consequences of the dual burden of malnutrition. Qualitative research into physical activity, nutrition, obesity related to adolescent perceptions and behaviors offers a critical understanding of the personal, social, and cultural aspects of the dual burden of malnutrition. Qualitative methodologies have been especially important in identifying context-specific factors in low- and middle-income countries (LMICs), providing insight into the barriers, enablers, values, and beliefs associated with physical activity, nutrition, and obesity

behaviors in these settings. One qualitative study of adolescents in India revealed domains related to health knowledge, family, and the school to have substantial influence on physical activity and nutrition behaviors associated with obesity.[354] Another qualitative study in Guatemala mirrored these findings, as adolescent participants identified physical activity and nutrition factors as necessary for achieving and maintain a healthy body composition.[355] Additionally, participants in the Guatemalan study identified lack of nutritious food options and prioritization of sports for boys over girls as barriers to a healthy body composition.[355] A study of adolescents in Iran revealed other gender-specific barriers to physical activity for girls.[356] Knowledge of this kind is necessary and relevant to the study of and intervention into the dual burden of malnutrition and nutrition transition in Haiti.

Important nutrition-focused literature and data sets are available for Haiti, but nutrition represents only one-half of the paradigm for achieving and maintaining a healthy body composition within the context of the dual burden; research on the physical activity patterns and behaviors of Haitians is minimal.[32,179,181,310,324,349,357–359] Previous components of this research project examined objective and self-report physical activity patterns of adolescents (see Chapters 2 & 3). These previous studies helped to inform the conceptual model presented in Chapter 1, but did not capture the context of these behaviors, not just within the broader context of the early stages of nutrition and physical activity transitions, but also within the sociocultural context in which physical activity is undertaken every day as it relates to the dual burden of malnutrition. In order to examine how adolescents' physical activity attitudes, beliefs, and behaviors are shaped through their social, relational, and environment context, this study aimed to better understand adolescents' definitions of, beliefs about, and experiences of key constructs in physical activity, nutrition transition, and dual burden research.

4.2 Methodology

4.2.1 Definitions

In this study, *adolescents* were defined as children 10-15 years old, applying the World Health Organization (WHO) and United Nations International Children's Emergency Fund (UNICEF) definition of *early adolescence*. Because the purpose of this study is to evaluate the attitudes, beliefs, and behaviors of adolescents regarding general health, obesity, and physical activity, the following definitions were applied: g*eneral health* was defined as "the state of total physical, mental and social wellbeing, not merely the absence of disease or infirmity"; *physical activity* was used in this study to describe all activities involving movement of the body that requires energy expenditure; *obesity* was used to describe the condition of extreme overweight and body adiposity.[360] To best capture the views of adolescents in a low-resource setting, participants were first asked to define these terms within the focus groups. Then, if any discrepancies between the groups' definitions and the WHO definitions were present, clarifications were made prior to the questions regarding attitudes, beliefs, and behaviors.

4.2.2 Sampling, Recruitment, Consent, & Participant Eligibility

A subsample of adolescent participants was selected from a larder study previously physical activity behaviors; the design, measures, and study procedures have been previously described in detail (see Chapter 2). Briefly, these students were recruited from one public and one private elementary school in Cap-Haïtien, the second largest city in Haiti. The city is a low-lying, densely populated urban area bordered by a small airport, a major road, a canal, and the ocean. During the rainy season, it is vulnerable to flooding due to the topography and lack of waste and drain-water infrastructure. Much of the housing is of poor quality, unfinished and

lacking in sanitation, water and electricity. The two schools from which participants were recruited were selected based on a previously-expressed interest in research participation and their location within this urban, poor geography.

Study coordinators contacted school administration for permission to conduct research on school grounds. School administrators distributed an informational flyer regarding the study to parents and caregivers of students in the desired age-range. Parents and non-parent caregivers of adolescent participants were recruited from either elementary school, consented, and paid 300 Haitian Gourdes (~$4.70 USD) for their time and travel expenses. Adolescent participants provided verbal assent and were compensated for their participation with a small bundle of school supplies. Participants were screened for eligibility based on the following criteria: caregiver interest and consent; aged 10-15 years; good health (no fever, congenital health condition, or helminth infection); registration in school for the 2016–2017 academic year; and present at school on days focus groups were held.

4.2.3 Study Procedures

Over the course of the 2017-2018 school year, semi-structured focus groups and structured observations were held at two primary schools in Cap-Haïtien, Haiti. The focus groups centered on key themes derived from physical activity, nutrition transition, and dual burden research; specifically aimed at understanding components of the analyses undertaken in Chapters 2 & 3. Each focus group comprised 6-8 adolescent students (see Table 4.1).

Each focus group was conducted by a trained, experienced moderator who was a member of the communities represented in the focus groups and fluent in Haitian Creole and English. All focus groups were conducted in Haitian Creole, ranged from 55-75 minutes in length, were digitally recorded, and transcribed in Creole and translated into English for analysis. The

research team member responsible for transcription and translation was present at all three focus groups, and fluent in Haitian Creole and English. Focus group transcripts were uploaded into QDA Miner 4 Lite qualitative analysis software and coded for themes.

Theoretical constructs from adolescent physical activity, nutrition transition, and dual burden research were employed in the design of the focus group questions and the codebook used for focused coding procedures.[361] Themes clustered around overall positive and negative health behaviors regarding general health, obesity, physical activity, and nutrition/diet. These four top-line themes were then sub-divided into detailed categories that emerged through analysis of participants' responses: barriers to good behaviors/ causes of poor behaviors; enablers of good behaviors/ solutions to barriers; disadvantages/ negative effects of behaviors; advantages/ positive effects of behaviors; negative attitudes, beliefs, or values; positive attitudes, beliefs, or values; good foods; bad foods; and gender differences. Analysis of top-line themes and subcategories revealed patterns in the participant responses, thus comprising the findings reported here.

Structured observations were conducted in the mornings and afternoons during school arrival/departure and mid-day during school recess in 30- to 75-minute sessions. Observations were conducted at each school over the period of one school week (Monday through Friday) and assessed the action, actors, and the environment in which school-based physical activity occurred. The purpose of the observations was to see adolescent physical activity in real-time in the school environment, to triangulate previous quantitative data collection (see Chapters 2 & 3), and to corroborate focus group findings.

4.3 Results

4.3.1 Participant Characteristics

A total of 21 adolescents participated in three different focus groups. Table 4.1 describes the groups' age, gender, and school distribution. A total of four structured observations were conducted, two at each school. Observations emphasized differences in physical activity behaviors between genders and body compositions.

Table 4.1. *Participant characteristics from three focus groups (n= 21)*

	No.	%
Age		
10	3	14.3%
11	4	19.0%
12	5	23.8%
13	4	19.0%
14	3	14.3%
15	2	9.6%
Gender		
Male	8	38.10%
Female	13	61.90%
School		
Public	7	33.3%
Private	14	66.7%

4.3.2 Structured Observation

The two schools observed in this study both reside in a densely population urban area. One school is located along a major two-lane road, bordered by a canal and the airport. The other school in located on a one-lane collector road (still servicing both directions of travel; not one-way) that directs traffic from the major road running through Cap-Haïtien to arterial roads, and sits across from a large, busy church. Both schools are surrounded by heavy foot and motor vehicle traffic. Food, clothing, and other market vendors arrive early in the morning—at least one hour prior to the start of school—in order to set up their stalls for the day. Stalls are not permanent installations, but rather are most frequently blankets or tarps spread on the ground

upon which the goods are displayed for purchase. A stall space around the school is considered a highly sought-after selling space, as there is heavy traffic from students and their caregivers coming to and from school. Food vendors sold pre-packaged foods *(e.g.*, chips, cookies, crackers, candies, etc), pre-packaged sugar-sweetened beverages *(e.g.*, juices, sodas, shaved ice with flavored syrup), water bottles or sachets, freshly-prepared fried foods (*e.g.*, banana, dough, horse meat, hot dog, *pacquet*[1]), other prepared foods (bread with peanut butter, hard-boiled eggs, boiled manioc, rice and beans/peas, roasted peanuts), and fresh fruits and vegetables (avocados, bananas ,and mangos).[32] Vendors sold food items before and after school as well as during recess.

Hours of operation for each school were comparable, starting around 8 am and lasting approximately 5 hours, with 5-7% of the day dedicated to recreation time for the students. Both schools had limited outdoor recreational space. The courtyards in both schools limited movement, as space was crowded by the number of students present. One primary school had such a small activity space that recesses were called in shifts by age groups/grade levels. Though the other school had a much larger space for recess, almost all recesses were held across all age groups/grades. Table 4.2. describes the school environments. A previous study involving both schools revealed that there was no apparent relationship between outdoor space density and percentage of overweight/obese students.[32]

Due to the size constraints of the space and the number of individual activities occurring simultaneously, the overall scene appeared chaotic. However, a more detailed analysis revealed an informal structure to the recesses. Groups tended to form based on shared age and gender. The

[1]*Pacquet* is a street food served hot; it consists of deep-fried flour-based dough filled with meat, typically chicken, goat, pork, or beef.

Table 4.2. *School environment profiles*

School Characteristics	School 1 (private, urban)	School 2 (public, urban)
Total student population, #	568	690
Study participants, #	50	50
Recreation time, min	20	20
Outdoor space area, m^2	258	2850
Outdoor space density, m^2/student	0.4	4.1
Shade or green space	Yes	Yes
Latrines, #	3	4
Water pump	Yes	No
Electricity	No	No

occupation of the shared space seemed to have an unspoked designation. Lightly active and sedentary groups clustered against walls or in the shadows of buildings or trees to avoid the heat of the sun, with more active groups occupying into the lesser desired sunny spaces. Group activities included sitting or standing while eating and/or talking; games of *roslè*, *PEPSI*, karate, tag, or soccer (played with a water bottle).

Girls' and boys' activities were almost universally self-segregated, unless mixed groups stood together talking; any active actions were almost completely single-sex. Girls participated in *roslè* and *PEPSI*. Far more games of *PEPSI* were active, as the game does not require any equipment. Separately, boys played karate or soccer. Both groups played tag, but only within-gender games were observed.

Far fewer girls participated in active movement; the majority sat together in small groups socializing and talking. Many would linger in the groups long after food consumption had ended, some remaining sedentary for the entirety of the recess. Boys also sat in small groups eating and talking but appeared to eat as quickly as possible in order to disband and begin activity. An incredibly small number of boys were sedentary for the entirety of recess; the majority of this group being comprised of students that had failed to properly complete their homework and had to sit and rewrite their lessons from the previous evening.

On a few days, teachers brought chalk from the classrooms and helped the students to draw hopscotch diagrams on the ground. The author was asked to lend a handkerchief to tie around a rock and act as the "marker" for throwing onto the squares. Hopscotch was the only activity observed in which both boys and girls participated in an equal ratio.

4.3.3 Focus Groups: General Health

Responses from the adolescents in the focus group mirrored the WHO definition of general health and well-being. When asked to define a "healthy person," responses commonly included descriptions of someone without illness or disease, having few stressors, enjoying financial freedom, practicing good overall hygiene, eating well, getting regular physical activity, and dressing well. Adolescents also frequently mentioned receiving regular medical check-ups from doctors or hospitals to monitor ongoing health.

General Health Values

Respondents views of general health largely described the advantages of good health and quality of life values. Immediate, or short-term advantages of good health clustered around being stress free, performing everyday activities related to the home and school, and having the freedom to act as one pleases.

> I must be healthy to learn. (M, 14)
>
> Personally, I consider [my health] as a benefit for my mother because I can carry water for her when she asks me to. (F, 12)
>
> One must be healthy to avoid stress. (M, 13)
>
> When someone isn't sick, he doesn't have problems that trouble his mind.[2](F, 12)
>
> [A healthy person] can sit down somewhere to take some fresh air or watch TV. If he planned to visit a place, he can do it. (M, 10)

[2] It is important to note that male is used as the default gender, and comments apply to both genders unless specifically stated otherwise.

Adolescents' general health values also focused on being able to achieve future potential. Long-term values included the ability to provide for a family, to accept different opportunities in life, and to live into an older age. Students responses indicated a belief that poor health acted to prevent the achievement of these values. Here, the first instance of the word *staff* or phrase *using a staff* is presented, which was frequently used to indicate physical impairment associated with old age, thus requiring the use of a cane or walking stick for aid in pedestrian transport.

> A healthy life is when you have great possibilities. (F, 15)
>
> A health life is worth many things. A health life will enable you to develop your body and [provide] for the family. (F,12)
>
> When you become an elderly man… 70 to 80 years of age… you will need to be healthy to avoid using a staff too soon. (M, 13)
>
> [When] the person is sick, the sickness keeps him in bed, and he cannot do anything by himself. (F, 11)

Values of general health also focused on maintaining good hygiene and how one presents him/herself to the community, both with regards to respectful interactions with others. Perceptions of health also related to outward appearance; many comments addressed wearing good, clean clothes.

> He must take a shower daily, brush his teeth… after taking a bath he must put on new clothes, not dirty clothes. Don't play in the dust. (M, 14).
>
> Don't dirty yourself. Take good care of your body… He must take a shower every day, three times a day. Wear fashionable clothes even if you won't go anywhere. (M, 10)
>
> A healthy person; has respect for other people. He always takes a shower, he always washes his hands after using the toilets. (M, 13)
>
> When someone is healthy, it's when he is obeys to other people, when he pays attention to what he's told. When he is a well-educated person, when he is shows respect for his parents. (M, 10)

Causes of Poor Health & Solutions to Barriers

Participant examples of barriers to general health, or causes of poor health, frequently clustered around poor hygiene and poor diet. In order to achieve and maintain good health, a

person was described as someone with routine; respondents referred to doing activities "on time," indicating the action was undertaken at regular intervals. These routines included doctors' visits and (when necessary) medications, meals, hygiene, exercise, and sleep schedules.

> When someone eats on time, sleeps on time and takes a bath on time. When someone puts on new clothes after taking a shower. After taking a shower if that person puts the same dirty clothes, he will scratch his body. He is supposed to go home to change his clothes. And then you eat, drink and go to bed. (F, 12)

> Go to your doctor's clinic, take your medication on time. Do not eat junk food which can affect your health. Do not drink soda, drink natural juice instead. (F, 11)

> When he is healthy, most likely, he has a well-balanced life. If he is overweight, he must do sport to shed pounds, and then he eats on time. Moreover, he eats good nutritious food, he doesn't eat junk food that can destroy his life. (F, 15)

4.3.4 Focus Groups: Obesity

Understanding adolescents' views of body composition was necessary in order to understand how they defined obesity. When describing individuals with unhealthily low body weight, respondents called these persons *skinny* or *tchòk, tchòk*, the former referring to an underweight or thinning child, and the latter referring to a severely malnourished child that is either wasting or stunted in growth.

> He is skinny, and then he is as thin as a feather. If he doesn't tell someone [that he is healthy] then you cannot know. (F, 14)

Adolescents described a healthy person using statements related to body adiposity, calling people *byen devlope* (well developed), having *good shape*, and/or *strong*. Interestingly, when asked to define obesity, a cultural difference in views of larger body composition emerged. When asked to further explain the body composition of a *byen devlope*, respondents described a person "not too skinny" with "some fat," but not "too much fat" or "too big." In a sense, overweight was described to be acceptable, but obesity was not. The words *fat* and *big* did not carry a negative connotation; these terms can be applied to a *byen devlope* or someone with *good*

shape. Instead, the word *boxy* was frequently used as a descriptor of body composition indicating obesity and carried a negative connation.

> For example, that person can be big, he is almost boxy. But not that big, as an elephant. Looking at this person, you'll say he has a good shape. She is big, but not boxy. (F, 14)
>
> When you are big and strong, boxy people will complement you for that. (M, 13)
>
> When they are too big, I don't like a boxy person. (F, 11)

Causes of Obesity

In respondents' views, obesity is rooted in varying causes, clustering around themes of naturally occurring obesity or behaviorally induced obesity. Natural obesity was understood to be hereditary or a natural change in body composition that occurred over time.

> Someone who is big naturally can be obese. That can happen as time passes by this person is gaining weight. That's how someone can become obese. (F, 11)
>
> Sometimes the kids were born obese. It's natural. The genes transmit obesity to the kids. (M, 10)
>
> Some children can become obese… it is because of their mother! She [the mother] is obese, so he [the child] is obese. (M, 13)

Participants also believe obesity to be caused by poor dietary behaviors. In certain instances, obesity may be caused by overeating, a behavior the adolescents believe parents and caregivers are responsible for monitoring in their children. But in other instances, it is caused by an unvaried diet consisting of certain unhealthy foods.

> He becomes obese because of his mother… his mother gives him too much food. (M, 13)
>
> …Many of the times their parents are responsible for that. Whatsoever the kids ask for they would give it to them. "Mom, I want milk." "Here it is." "Mom, I want that." "Here it is." So they never refuse anything to their kids. That's how they become obese. (F, 12)
>
> When someone gets a bad habit in eating fatty food. His actual growth isn't natural. He becomes obese as he eats some kinds of foods that he shouldn't. Those foods affect his body. (F, 10)
>
> When someone is obese, someone is eating too much junk food that affects his system. He is eating fast food in the streets. (F, 15)

Finally, participants describe scenarios where individuals become obese after taking steroid injections. Men and women alike turn to anabolic steroids as a means of gaining a

socially desirable body shape. Participant responses generally focused on future regret of steroid use due to long-term health outcomes.

> When people are taking steroids to gain weight, they can become fat. (M, 11)
>
> Some people were skinny, as they want to gain weight, they are taking steroids. They are taking *ti polis*[3]… (M, 13)
>
> …They want to become big, they start taking steroids, but as they gained too much weight, they regretted it. (F, 11)
>
> …Those who are taking steroids become obese. Becoming boxy doesn't do any good to their body. They will be in trouble in the future. (F, 12)
>
> Taking steroids can be the main cause […] So, he takes injections [steroids] in order to gain weight. (M, 12)
>
> It is a bad thing, because taking steroids to get big isn't natural… You won't feel good in the future. When sitting down on a chair, their neck gets stuck in their shoulders.[4] They have big cheeks. (F, 10)
>
> The ones who become obese by taking steroids will never get back to his natural growth, and they tend to get other health complications. They get sick because of that. (M, 14)

Participants universally agreed that there was not one single cause of obesity. Instead, participants often alluded to varying etiologies of obesity, which were based on the individual circumstance of the obese person in question.

> For a category of people, it's not because they are taking steroids that will make them obese, they are big/fat naturally. They don't have to eat a lot to become fat. For another category, whether they have a mind to take steroids, such as ti polis, to get weights it won't work for them. But for a third category, even if they are not taking steroids, that won't make any difference. They will remain the same neither big nor skinny because that is their natural growth. (F, 11)
>
> For example, it can be natural… it's simply natural, because some kids didn't breastfeed, but they become big. You wonder, "How come a child didn't breastfeed then he becomes so obese?" It's the genes that transmits the characteristic traits to the child. (M, 13)

Advantages & Disadvantages of Obesity

Adolescents readily named many advantages and disadvantages for those persons with fatty body composition. Advantages clustered around social status related to a large size,

[3] *Ti polis* is the Haitian Creole word describing a syrup-based anabolic steroid.
[4] This is an allusion to the *boxy* shape of an obese person.

reiterating the cultural norms regarding body composition; being *fat* was connected to socioeconomic status where food is abundantly available, providing the opportunity for overconsumption, and thus weight gain. Other advantages related to having strength and an appealing body shape that garners compliments from others. The advantages applied more to overweight, not to obesity.

> When someone is fat, the benefit is when looking at your child they say, "Oh oh! Look at this child! He is big. He is cute." (M, 10)
>
> When a child is obese, he can help his mother do the house work. His mother can ask him to go and seek some water at the fountain for her. But, if he was a skinny child, he may not be able to carry a gallon of water for his mom. (M, 11)
>
> Haitian folks often think of obese people as rich people. I remember when I was a kid, I used to be like that. Same thing when you meet a bald man in the streets. (M, 13)
>
> When you are big and strong, not boxy, people will complement you for that. Naturally Haitian men prefer strong women with big butts. That's the reason why lots of Haitian women take steroids. It is said that they used to take some kinds of injections to develop their butts. (M, 10)

Respondents expanded upon an appealing body shape as advantageous, and again the concepts of dress, clothing, and self-presentation were associated with a desirable health status, in this case a desirable body composition. Being *big* is believed to help one to look best in his or her clothes. These benefits apply to overweight, but not to obesity.

> When wearing your clothes and people say you look big… you look good in your clothes. (F, 12)
>
> When a man is big, and then he has a date with someone then she complements him for the fact that he looks good in his clothes, "Please always put that on." Then he feels happy for such a complement. (M, 14)
>
> When you are big, you wear good clothes, you look good… as you walk in the streets some people are complementing you because of that, and you will feel happy. You will feel happy whenever someone tells you that you are big, you are fat. (F, 10)
>
> When someone is big, when she puts on her clothes and then her neighbors complement her for that and wish to see those clothes on her always. (F, 10)

Despite the potential social advantages, participants shared disadvantages to excessive body fatness. Again, responses distinguished between overweight (being *fat* or *big*) and obesity

(being *boxy*). Obesity had a negative connotation and was associated with poor health outcomes, but not overweight.

> He can be fat, but he is not sick. Too fat? Then he can be sick. (F, 12)
>
> That person may not feel comfortable in his body, he may not be able to run. Everywhere he goes other people will look at him saying that he is too fat. His growth doesn't do him good anymore. Others may even ask him "What do you eat? Because being fat isn't doing you good. You are too fat now!" (M, 14)

When pressed to name some negative consequences of overweight, not obesity, the participants struggled to name any. Generally, adolescents did not believe there to be disadvantages to being overweight, but only if the individual did not become obese.

> I don't really know... the fat person may not feel at ease in his body… But, often times *being obese* will result in health problems, not being big. (F, 15)
>
> His growth may or may not do him good. Don't grow too much! (F, 10)
>
> Someone who is too fat, he cannot walk. Someone who eats any kind of food… that affects his health in return. But, he can be big and still be healthy; it's not valuable for everyone. (F, 12)

Disadvantages largely focused on negative health consequences. Again, disadvantages were associated with obesity, rather than overweight. Obesity was associated with heart problems in adults. Participants described respiratory issues as a negative health outcome of obesity for all ages.

> When someone is too big, he tends to get sick easily… because when you are too big it is a kind of sickness for you. (M, 13)
>
> Older obese people often have high blood pressure problems […] walking a few steps from home to a short distance… it makes him feel out of breath. […] That's a disadvantage. (F, 12)
>
> …He will be out of breath for nothing! And, if he doesn't step back, he may die in a heart attack before he gets a staff. (F, 11)
>
> Being obese will cause the person to have high blood pressure, he will be out of breath for nothing. (F, 10)
>
> When he is exhausted, he sounds like he is out breath. The kid or the man… they breathe too hard for nothing! That is the result of obesity! (F, 10)

The phrase *out of breath for nothing* was used repeatedly to describe individuals that panted or experienced shortness of breath after minimal physical movement. This was seen not

just as a disadvantage to obesity, but also as a barrier to movement, when was also a frequently cited disadvantage of being obsess. Limitations to activity were seen as a detriment to everyday functioning and an undesirable outcome. Responses implied that inactivity and limited movement were shameful or embarrassing states.

> They don't feel good […] Being obese makes them unable to take a long walk and stand up. All they can do is sit down every day. (F, 12)
>
> …They don't feel at ease with their body. They have lots of difficulties playing with other kids, so other kids don't like them or ask them to play. (F, 12)
>
> …Even if he does want to go outside to get something, he can't walk. So he would be sitting down and have to ask someone else to get it for him, because he is too fat. (M, 13)
>
> He may not be able to lift [a gallon of water]. Because, being too fat, he could even fall on the ground as trying to lift it. [Other participants laugh at this] (M, 11)
>
> They don't want to fall when they are doing sports to avoid others making fun of them. (F, 11)

4.3.5 Focus Groups: Physical Activity

Participants displayed a broad understanding of physical activity. When asked to define physical activity, they provided a general meaning and description of examples. Comments made by the group indicated that exercise and physical activity were different concepts, and that exercise was a type of physical activity. Both genders provided examples of activity commonly focused on sports or exercise, though girls also provided examples of utilitarian activity relating to housework and transportation. Certain games or activities were associated with different genders.

> GIRLS:
>
> [Activity is] when someone is doing sports. When she is playing hopscotch, *roslè*[5], and playing soccer. (F, 11)
>
> We do all duties girl can do… Do the dishes and clean the house. Anyways doing the housework is a girlish task. (F, 11)
>
> We play tag and we do *PEPSI*.[6] (F, 10)

[5] *Roslè* is a game similar to the game of *jacks* in the US, more typically played by girls than boys.

> As for me, going up and going down the stairs daily is my sport. (F, 15)
>
> I go and seek water. I used to do all types of activities girls do. I do the dishes. I wash my clothes. I cook. After I am done, I try to go to play soccer. Sometimes I cannot because it is first for boys. (F, 12)
>
> I sometimes do the dishes. When I am going up stairs or when I am walking to school… these are my activities. (F, 14)
>
> BOYS:
>
> You can make movement with your body… you can relax[7] your muscles. (M, 13)
>
> Just like you're playing soccer; you're playing basketball, volleyball, and tennis. You are moving, and your muscles will get relaxed. (M, 13)
>
> Playing soccer, jogging and, doing sports… Sometimes going for a walk and going to the beach to swim. Girls play *roslè* and *PEPSI.* We play soccer or do karate. (M, 11)

Interestingly, the gender differences in activities were commonly agreed upon as the status quo. However, the following exchange demonstrated that some girls would like an equal opportunity to play soccer, even though it is typically only enjoyed by boys and men.

> Girl 1: Not only boys can play soccer. Girls can, too. Soccer wasn't invented for men only. (F, 12)
>
> Girl 2: When girls are playing soccer, people will laugh at them saying that they are not boys, and soccer wasn't made for girls. Even me, I would rather see boys practice soccer. (F, 11)
>
> Girl 1: We would rather be active, too, though. (F, 12)

Barriers & Enablers of Physical Activity

Respondents unanimously cited only a few short-term barriers to physical activity: pain from over exertion, muscle strain, and fatigue or fatigue-induced headache were cited as the only potential disadvantages to physical activity. Participants generally saw these disadvantages as temporary, and potentially remedied with minimal resources. Remedies included rest, showering, repeated practice, and treating pain or injury with pain relievers and massages.

---

[6] *PEPSI* is another game typically only played by girls. Girls stand across from each other or in a circle and perform coordinated hand movements, clapping their own or each other's hands, and trade lighthearted insults back and forth. It is similar to American handclapping games performed to a song or rhyme like "Miss Mary Mack."

[7] The words *relax* and *relaxation* were used to describe the act of stretching, or to describe the amplification of blood flow to the muscles associated with physical activity and exercise.

> When you are doing too much exercises, you will have a pain, you should not do sports on daily basis without taking a break. It is not good. Because you take a little time to rest so that when going back to the gym your body will be more flexible. You need to rest. If you could do it every other day it would be better. (M, 12)

> When someone is doing sports, some movements may cause you to have pain in your body. Therefore, you should stop and rest. (F, 10)

> …Sometimes you may not feel at ease when doing sports. If you had a pain, it will disappear as you are practicing. (M, 13)

> When someone is doing sports, you may not feel food. You can ask someone to give a massage sometime… rub your back. Then a few days later you can start over. (F, 12)

> That can happen also, you are too hot, too much heat, you're perspiring, you may have a headache. You should shower… Sometimes we take a pain reliever for the headache. (M, 10)

> By doing physical activities, we may feel a pain on the first day, the next day you have to keep on even if your body hurts, the pain will go away as you keep on. Your body will learn. (F, 15)

Long-term barriers to physical activity commonly centered around a deficiency of resources. Limited space in the built environment was the most frequently cited restriction on activity. Typically, other participants would echo this limitation and subsequently mention lack of equipment for certain games or sports.

> At home, I don't do physical activities because I don't have enough space. Because I don't have enough space to run, to play. Sometimes, I just sit down and sleep. (M, 10)

> A narrow space. Even for pedestrians there is not enough space to walk. (M, 13)

> For example, you don't have a huge yard to do those activities such as playing tag with little friends or playing soccer. (M, 13)

> We don't do sports at school. We don’t have space and there are no balls or ropes. If they would schedule sports every Friday, it would be great. (F, 14)

> When I play soccer, there isn’t a ball. We had a ball, but someone took it. My cousin had a ball, but it deflated, so now we play with water bottles. I can use a water bottle as a soccer ball, but I’m not as fast with it. (M, 10)

However, participants also cited the use of their imagination as a solution to these barriers. Using substituted items was discussed as an enabler of activity, even if not considered the preferred first option.

> I don’t like playing with a water bottle instead of a soccer ball, but I will do it because I would rather play than nothing. (M, 10)

> It is my mind that enables me to do activity. If my mind says do it, I will do it. If my mind says, 'This is a soccer ball,' then I believe [the water bottle] to be a soccer ball. I imagine it is the right way. (M, 13)

> I play jump rope at home with the clothesline as long as my mother can't catch me with it. I have to be careful and put it back. My auntie watches me, too, so I have to be careful. (F, 10)

Finally, participation in sports was contingent on a physical capacity for activity, and respondents commented on a lack of appropriate dietary energy as a barrier to undertaking sports. Participants frequently mentioned a preference for sedentary behaviors over physical activity when experiencing malnourishment or hunger.

> When you're malnourished. And then, you get sick. …your doctor advises you not to work too hard. (F, 11)

> When you don't have enough to eat. You are too tired. You are weary. You cannot do any activity when you are too hungry. (M, 14)

> When I am not in good health… if I don't have food in my belly, I will wait until I eat so that I can do my activities. I cannot fetch water until I have energy, but sometimes I need to fetch water to help prepare the food I need for the energy. (F, 14)

> When I am hungry, I do not play soccer with my friends. I will stay home. I will sleep or watch TV. (M, 10)

Conversely, participants cited good physical and mental health as enablers of physical activity. More specifically, participants discussed having the willpower to do activity, even when tired or hungry.

> Most of time it is because you are healthy that enables you to play. (M, 13)

> You just feel like doing it, then you do it. The mind will help you to do it if you are tired. (F, 10)

> The mind enables you to see, to talk, to hear. It enables you to do everything. My mind will help me go even if I am tired or hungry… I must get water… I must build a fire. I will go do this, then finally I can eat, shower, and rest. My mind knows what I need. (M, 13)

Additionally, proper nutrition and adequate energy were also named as necessary factors for participating in physical activities.

> We do activity because we are in good health. If we have enough to eat, then we can move. (F, 12)

Advantages of Physical Activity

When asked about advantages of physical activity, participants cited numerous benefits. The majority of responses clustered around general health and wellbeing—whether it be to maintain current health and wellbeing or to recover from sickness or obesity.

> When someone has a big fat belly, he must always do sports to shed pounds. (F, 10)
>
> When someone is obese… when someone is too fat, he is supposed to do sports… that way he would lose weight. (F, 12)
>
> If you're healthy, and you would like to stay healthy, do sports! (F, 11)
>
> If it happens that you come down with a sickness, you should do sports to help release your veins[8] and help your breathing. (F, 11)

Other responses indicated physical activity provided beneficial effects on body development. This was commonly applied to the proper growth and development of the respondents and their peers. The term *fast* was used to indicate timely, age-appropriate growth, as opposed to stunted growth due to undernutrition.

> [Physical activity] is good for you and even better when a kid, because you'll be growing up fast and healthy. Your body will develop. (M, 14)
>
> Doing sports will prevent you from getting sick so easily, so you can grow up fast and healthy. (F, 12)
>
> Physical activity will enable you to grow up fast and healthy. Moreover, it can help release the veins. (F, 15)
>
> When practicing sports, your body will develop. Your veins will release and you can develop best. Even if you are older, your veins will release and you can stay active. You will avoid a using staff too soon. (M, 10)

The concept of *releasing the veins* was frequently mentioned. As indicated in the last comment, beyond its application to the healthful growth and development of adolescents, the concept also had implications for adults, perceived as a means of maintaining their strength and flexibility for an active lifestyle over the life course. Again, older age and physical impairment was linked with *using a staff* as an aid in pedestrian transport.

[8] Similar to the previous footnote on *relaxation*, *releasing the veins* refers to amplifying circulation and helping blood flow to the muscles, in order to maintain flexibility for an active lifestyle.

> Doing sports enables your body to get relaxed. This is the advantage: relaxing the body and releasing the veins will help you move always. You will be able to move all your life. (M, 14)
>
> What I could say is, even if you are an elderly man, you should do sports in order to relax your muscles and release the veins. You want to avoid using a staff too soon. (F, 11)
>
> Even when I am an older woman, I need to think about sports or doing the chores… not chores just for my family, but chores for my health. I need to release the veins and stay active. (F, 15)

4.3.6 Focus Groups: Nutrition & Diet

Of most interest, comments regarding the relationship between diet and health largely clustered around the nature of foods consumed, which was dichotomous; foods were either considered *good*, *nutritious*, or *natural*, or they were deemed to be *bad*, *unhealthy*, or *junk foods*. Responses directly linked foods in the good category to positive health outcomes, and foods in the bad category to obesity, sickness, and generally poor health. Many quotes previously provided touch on these distinctions as well.

> BAD FOOD:
>
> There are some kinds of foods and sodas that we should not drink, because they are responsible for obesity. Too much flour or rice… flour can make you fat. (F, 12)
>
> A person gets too fat when he feeds himself on too much wheat flour, this way he will fatten up. (F, 12)
>
> There are some types of food that you may be eating that may not be good for your body. (F, 10)
>
> We must eat natural foods to take care of ourselves. Do not eat junk foods which can affect your health. Do not drink soda; drink natural juice instead. (F, 14)
>
> GOOD FOOD:
>
> Eating food produced locally is good. (M, 12)
>
> Eat yams, bananas, barley, and malt… then you can also eat sweet potatoes and other things that will do you good. (M, 12)
>
> You should eat natural food daily and drink natural juices. (M, 14)

Participants demonstrated an awareness that soda and other sugar-sweetened beverages were unhealthy and could lead to excessive body fat. As an alternative, respondents suggested drinking *natural juice*, meaning the unsweetened juices taken

from fresh fruits. Common examples of fresh juice include guava juice, grapefruit juice, mango juice, passion fruit juice, and soursop juice.

Participants also frequently mentioned a preference for locally grown foods over imports from the Dominican Republic, US, or other Caribbean nations. Locally grown produce is commonly viewed as healthier and better tasting than imported produce, even those the imported food items are frequently less expensive.[134]

4.4 Discussion and Conclusion

4.4.1 Understanding the Context of the Dual Burden of Malnutrition

These focus groups revealed that Haitian adolescents have a general understanding of the universal definitions and applications of the concepts of general health, obesity, and physical activity. Their understandings implied a logical link between the concepts, connecting the maintenance of good health to the avoidance of the negative consequences associated with poor health and obesity, which was equally rooted in a balance of nutrition and physical activity. These findings mirror those of qualitative research in adolescents in other LMICs.[354–356] Within a low-resource context, the necessity for good general health and physical activity is driven by the same motivations as in a high-resource context; the desire to provide for one's family, actively function in society, and live into old age are all motivators for achieving and maintaining a balanced, healthy life. This is likely driven by the traditionally active lifestyles of Haitians. Though the country is experiencing increased urbanization, economic, and technologic transitions, subsistence agriculture largely dominates production, and husbandry is widely practiced within urban and suburban settings.[36–38,134,320] Furthermore, active transportation, either

solely or in tandem with public commuting methods, is predominantly relied upon for conveyance between the home and school or work.[320]

The findings presented in this chapter expand upon the work presented in Chapters 2 and 3 by providing the contextual background in which Haitian adolescents' diet and physical activity behaviors take place. The results presented in Chapters 2 and 3 largely informed the behavioral and biological factors discussed in the conceptual model presented in Chapter. The findings presented here better inform the immutable factors related to demographics and family structure, as well as the contextual factors related to the socio-cultural environment, the physical environment, and individual factors related to personal values, beliefs, and behaviors.

When analyzing health values, beliefs, and behaviors within the Haitian cultural context, some unique perspectives arose. Primarily, attitudes regarding body composition, body image, and adiposity differed from those in high-income settings, and better resemble qualitative studies conducted in other LMICs.[354–356,362] Since body adiposity has a potentially protective effect in a low-resource setting experiencing endemic undernutrition, positive value is placed on excess body weight, though to a limited degree. While overweight is recognized as a significant risk factor for poor health in a high-income setting, responses in these focus groups reflected a positive connotation for higher body fat. Indeed, separate terms were used to describe overweight individuals, differentiating them from excessively overweight or obese individuals. A *big* or *fat* person is seen as healthy, with an ability to function normally in the everyday circumstance. This is even a desirable status for body composition; *big* individuals are considered well developed and strong, with a high capacity for executing strenuous activities like fetching water. However, once an individual is obese, this individual is described as *boxy,* and the term carries a negative connotation. Negative health consequences associated with

overweight in a high-resource setting are not applied to *big* or *fat* individuals, but instead this category of excess body adiposity is bypassed, and all negative health outcomes are associated with obesity.

It is generally accepted that physical activity can improve flexibility and circulation. However, these focus groups revealed another unique perspective regarding the role of physical activity in cardiovascular health. The phrases *relaxing the body* and *releasing the veins* were used to describe the physiological benefits of exercise and physical activity. Both concepts suggested high value is placed on flexibility and proper blood flow for adolescent growth and development as well as maintenance of health into old age. These unique terms for healthy flexibility and circulation indicate a vague, yet paradoxically concrete link between physical activity and cardiovascular health.

The positive views of enhanced blood flow described by Haitian adolescents here resemble a previous study of bodily fluids in Rwanda. Both healers and patients consider the perturbed or hemorrhagic *flow* of bodily humors to be a sickness; individual health is dependent on continued, unobstructed blood flow.[363] This notion is deeply rooted in the country's history and persists in the discourse of current popular medicine.[363,364] The responses presented here lend a small glimpse into the Haitian view of blood flow's relationship to health and suggest a similar perception to that of Rwandans. Further qualitative exploration of this concept is required to better understand the Haitian populations' beliefs regarding blood, the bodily humors, and their role in health and wellness.

Interestingly, adolescents' responses frequently mentioned steroid use as a means of gaining weight and achieving a desirable body shape. Respondents mentioned receiving steroids from medical professionals for health-related purposes as well as purchasing steroids outside of a

hospital or clinic. Literature addressing steroid use outside of medical recommendation for the cosmetic purposes related to gaining weight—outside of body building in a high-income setting—is not available. Key informants described steroid use and availability in Haiti as "extremely common," but formal corroboration of these findings was not found. This is will be an important cultural perspective to further explore and consider in future public health work that addresses the achievement and maintenance of a desirable body composition in Haiti.

The qualitative findings reported here echo the results of previous quantitative work to understand adolescent physical activity in Haiti (See Chapters 2 & 3). Of most relevance, the gender differences in physical activities reported in the focus groups corroborate findings in self-reported and objectively assessed physical activity data; females typically experience fewer minutes of physical activity relative to their male counterparts, and when they do, it is largely utilitarian activity associated with commuting or household maintenance (See Chapter 2). Interestingly, while the focus groups reported here revealed general agreement on the status quo relating to cultural norms for gender roles and the subsequent differences in physical activity between males and females, they also revealed a desire on the part of female participants for equal opportunities to experience physical activity. The gender-specific barriers to physical activity and the desire from female participants for equal opportunity to participate in sports cited here matched those cited in Guatemala and Tehran.[355,356]

Previous quantitative analyses indicated a strong association between dietary diversity and physical activity outcomes (See Chapter 3). Participant responses from the focus groups not only reflected beliefs that unvaried nutrition is directly related to poor health outcomes, but also that adequate nutritional energy is necessary for participation in physical activity. While it is widely known that nutrition and physical activity are linked with positive health outcomes, the

results presented here highlight personal beliefs associating the connecting between food and performing everyday activities for general health and basic survival.[6,311,342,365,366]

4.4.2 Limitations

As the focus groups were limited to a single contact point, it was difficult to fully explore certain health-related topics. While certain concepts reached saturation, other topics would have benefited from conducting more focus groups. Generalizability is also limited, as the focus group numbers were small. The sample methods also limit generalizability to the rest of the country and to other LMICs; sample described here represents only an urban and a poor segment of Haitian adolescents. However, as Haiti has been experiencing rapid urbanization—60.88% of the population lives in urban areas with an annual rate of change hovering around +3% and an overall increase of >10% in the last ten years—examination of the urban poor is becoming more and more relevant to public health research in the country.[102,303]

As the focus groups were translated from Haitian Creole to English, cultural differences in language, inflection, idioms, or nuances of meaning may be lost. This, as well as possible acculturation of meaning, can influence interpretation. Furthermore, the presence of the author likely skewed some of the behaviors recorded during structured observation. For example, the focus groups revealed hopscotch to be a preferred activity for the girls. However, many of the students were excited to show off their hopping skills for a new audience. Indeed, it appeared as though the teachers were also eager to set up the hopscotch games for the purposes of the observation. In the same vein, many individual displays of karate occurred. Key informants commented that soccer is a far more common activity during recess, but with a lack of water bottles and an abundance of new faces, the children were eager to show off their jumping and punching skills for the observers.

4.4.3 Conclusions

Perhaps one of the most striking findings from this study is adolescents' perceptions of barriers to physical activity and the readily achievable means by which to overcome them. As barriers focus primarily on a lack of structure and equipment, providing organized physical activities through the schools, accompanied with appropriate gear necessary for the activities, would directly overcome multiple barriers at once. Furthermore, interventional programs of this nature could be tailored to address the gender disparities in physical activity outcomes, giving special focus to equal inclusion of both boys and girls.

Of equal importance was the emergence of a cultural acceptance of overweight. This represents a unique barrier to public health intervention in the dual burden of malnutrition in Haiti, especially considering that overweight is medically considered as *pre-obesity*.[77,83] Programs designed to educate the public regarding body composition and to promote proper nutrition and physical activity will assuredly suffer lest they directly address this unique cultural perspective of fatness.

Most of the nutrition transitional and dual burden research has not considered physical activity within low income countries. Additionally, past physical activity research has not included evaluation of the low-resource context within LMICs. Studies addressing this gap in the research are necessary to effectively implement early intervention in the dual burden of malnutrition. Qualitative studies like this research project are a good way to gain knowledge of health values and behaviors, and a necessary means of triangulating quantitative studies by providing contextual understanding. This information can then be used to effectively inform and tailor assessments that meet the needs of this unique group, rather than directly transplanting methods developed in high-resource settings which may not translate to a different population.

Finally, the information on the barriers and enablers to physical activity presented here may help in the planning and implementation of culturally appropriate physical activity interventions.

Chapter 5: Final Discussion and Conclusions

5.1 Discussion of Findings

This study examined correlates of meeting the WHO recommendation child and adolescent physical activity (WHO REC) in four domains of physical activity: objectively assessed physical activity, self-reported school-based physical activity behaviors, self-reported transportation-related physical activity behaviors, and self-reported leisure-time physical activity behaviors. Several correlates of meeting the WHO REC were identified for Haitian adolescents aged 10-15 years. First, adolescent age and adolescent gender were consistently, significantly associated with meeting the WHO REC across all four domains; older adolescents and males had increased odds of meeting the WHO REC. Caregiver occupation was also significantly associated with meeting the WHO REC in all four domains; adolescents whose parent or caregiver worked vending in the market had an increased likelihood of meeting the WHO REC. Dietary diversity score was significantly associated with meeting the WHO REC in all four domains of activity; increased dietary diversity was associated with increased odds of achieving the WHO REC. Other variables related to SES and caregiver characteristics had significant associations with the WHO REC (*e.g.*, owning a car/truck, home or land ownership, access to a flush toilet), but these relationships were inconsistent across the domains of physical activity.

Physical activity research has shown a broad range of correlates and influences. As previously stated in this manuscript, a paucity of research has evaluated physical activity within low-income countries, and virtually no data is available regarding physical activity behaviors in Haiti. [113,144,311,312,334,335,367,368] As evidence from dual burden research has suggested that

combined physical activity and nutrition interventions hold potential for effectively addressing both extremes of malnutrition, filling this gap in the research is a critical first step.[10]

The dual burden of malnutrition is strongly associated with nutrition transition (see Chapter 1). There is strong evidence of the nutrition transition occurring in Haiti. Globalization has shaped the nutrition environment in Haiti; the country has increasingly relied on imported foods since the opening of the economy in 1985, and multinational food corporations have established a presence in Haiti, influencing food marketing, prices, and availability.[36–38,91,93,302] The economic effects of globalization have fueled rapid urbanization, with ~60% of the population living in urban areas—up by more than 10% in the last decade.[303] Adoption of advances in medicine, sanitation, and technology are all driving cultural and public health changes. Of greatest importance is the rise in overweight and obesity prevalence in the last decade; 38.5% of Haitian adults are overweight in 2016, and adult obesity increased by nearly 15% between 2008 and 2016.[301,305,369] Childhood overweight and obesity has also increased, though less dramatically.[304] Concomitantly, Haiti still experiences large scale undernutrition issues with nearly 47% of the population unable to cover its minimum dietary requirements, accounting for almost 5 million undernourished Haitians.[301] Chronic undernutrition affects nearly 22% of Haitian children.[38,301] This dual burden of malnutrition has further strained the health of the population and the health systems meant to treat them.

Long-term consequences of the dual burden of malnutrition include negative health outcomes related to malnutrition, increased healthcare costs, reduced productivity, slowed economic growth, and increased morbidity and mortality. This in turn perpetuates a cycle of poverty and poor health outcomes within Haitian families, communities, and the country as a whole. However, early intervention in this public health challenge offers a critical opportunity

for the recovery and development of Haitians' health and general well-being. Furthermore, focusing on the dual burden of malnutrition provides a unique chance for integrated intervention, focusing on all forms of malnutrition.

Nutrition interventions have shown wide ranging effects on the recovery and prevention of undernutrition in Haiti. Abundant literature is available concerning Haiti's nutrition and food environment factors. [179,181,310,349] Great strides have been made, as short-term undernutrition has decreased to under 10% prevalence as of 2017.[38] However, stunting prevalence remains unchanged in the last 5 years.[36–38] An explicit focus on the persistence of chronic malnutrition in Haiti will be vital to future dual burden intervention. Yet, nutrition-based research represents only one-half of the paradigm for achieving and maintaining a healthy body composition within the context of the dual burden; physical activity research is an equally critical component of dual burden intervention.

This exploratory study focused on possible points of intervention corresponding to the nutrition and physical activity behaviors of adolescents The adolescent growth spurt has been identified as a promising period for catch-up growth, potentially reversing previous nutritional inadequacies and mitigating the risk of adult chronic disease.[10] As adolescence is comprised of school-age years, and school-based interventions have shown potential for sustainability, developing a school-based physical activity and nutrition program for adolescents is a logical step in addressing the dual burden of malnutrition.[53,180] For example, establishing structured physical activity programming aimed at building lean muscle mass, paired with sufficient energy supplementation, has potential to benefit both extremes of malnutrition, helping undernourished and overweight/obese individuals achieve and maintain a healthy body composition. Energy

supplementation will be especially be of importance to these programs, as the need for fat mass in undernourished children cannot be disregarded.[179]

However, researchers should be cautious of directly transplanting physical activity and nutrition interventions that have been developed for high-income populations directly into a low-resource setting. Thus, before any intervention is undertaken in Haiti, a needs assessment focused on adolescent physical activity and nutrition behaviors is required. This research project aimed to fill a gap in the dearth of health data available for Haitian adolescents. It provides first-generation data and a baseline understanding of physical activity and nutrition values, beliefs, and behaviors. Furthermore, it assessed the methodological feasibility of two different physical activity data collection methods: self-reported physical activity behaviors across three domains (*i.e.*, school, transportation, and leisure) via interview surveys and objectively assessed physical activity via use of accelerometry study.

5.1.1 Feasibility of Methods

In Chapter 2, preliminary analysis was undertaken to characterize physical activity through two different data collection methodologies, as well as identify correlates of physical activity in Haitian adolescents. The research findings presented here indicated that both self-report and objectively-assessed physical activity behaviors can be successfully obtained in Haiti. Furthermore, associations between correlates and physical activity outcomes were consistent between the two data collection methods. The implication of these findings is an important one in a low-resource context.

Self-reported physical activity has historically been established as an acceptable measure of physical activity behaviors, though more recent studies look to combine both self-report and objective measures.[67,309,370–375] However, objective measurement of physical activity can both

time and resource constrictive, especially in a low-resource setting. Because self-reported data was successfully collected and analyzed, this justifies the use of self-report methods in future physical activity studies in Haiti. Using a less cumbersome technique that requires fewer overall resources is of great significance in continuing physical activity research in Haiti. As the IPAQ has been rigorously tested in multiple populations, future research should consider utilizing self-reported physical activity behaviors in Haitian adults as well.

5.1.2 Understanding Correlates of Physical Activity

Gender and Age

Chapter 2 identified initial correlates of meeting the WHO REC that were significant for in the objective data and across all three domains of the self-report data; likelihood of meeting the WHO REC had a significant, positive association with adolescent age and male gender. Age and gender are commonly studied predictors of physical activity in adolescents.[113,143,144,311,312] Though the significance and direction of the associations are not consistent, females are frequently shown to have poorer physical activity outcomes than their male counterparts.[113,143,144,311,312] This association was found to be true in the findings of Chapter 2. Female participants experienced decreased odds of spending enough minutes of MVPA to meet physical activity recommendations for their age group. Further insights into physical activity behavior differences were revealed in Chapter 4, as the qualitative focus groups identified cultural norms regarding girls' and boys' activity. For example, when asked to describe the types of physical activities in which they participate, girls offered a few schoolyard games that were mostly sedentary (e.g., *roslè* and *PEPSI*) or utilitarian physical activities related to household chores and caring for a family. The boys in the groups did not cite participation in these activities, but instead self-identified with sporting activities like soccer, basketball, and karate.

The gender differences were generally accepted as status quo, though some of the female participants expressed a desire to participate equally in sporting activities. Future intervention will require careful consideration of the gender differences in expectations of active behaviors while providing equal opportunity for achieving appropriate physical activity outcomes.

The preliminary models of physical activity also showed that age was a significant correlate of meeting the WHO REC. Younger children experienced fewer minutes of MVPA, decreasing their odds of meeting the WHO REC. This finding is somewhat unexpected, as physical activity research in children and adolescents has shown that activity decreases with age; previous research has been conducted in high-income settings, which may account for the difference. [313–316] More likely, the findings in this study are explained by the following: in this study, females experienced fewer minutes MVPA than males, but older females experienced more minutes of activity—generally of a utilitarian nature—relative to younger females due to the social expectations of women performing household chores.

Again, the qualitative focus groups presented in Chapter 4 expanded upon these results. Younger girls participating in the focus groups named chores as means of physical activity to a lesser degree than older female participants; indeed, the younger girls more frequently identified tag and other schoolyard games as active experiences, while the older girls primarily listed cooking, cleaning, and fetching water as their means of achieving physical activity. Because activity levels were relatively constant in males across all ages, the differences between older and younger females influenced the direction of the relationship between age and physical activity outcomes in this study. However, it is necessary to consider two potential limitations of these findings. First, this study only evaluated the values, beliefs, and behaviors of early adolescents aged 10-15 years; data for children ≥5 years, later adolescents 15-19 years, and

young adults ≥20 years were not examined. Second, these results are from a needs assessment. The nature of a needs assessment does not hold the same minimum for sample size as an intervention or evaluation study, thus the association between age and physical activity outcomes in Haiti may present differently in future studies with larger participant groups.

Socioeconomic Status and Nutrition

Also significant were variables related to SES; household access to a flush toilet, number of rooms in the home, home and land ownership, and household ownership of transportation methods all had an inverse association with physical activity, and caregiver occupation in the market had a positive association. Previous studies have shown an inconsistent relationship between SES and physical activity.[144] Access to a flush toilet in the home is rare amenity in Haiti, associated with a higher SES. Only 9% of households surveyed in 2017 had access to a flush toilet.[38] Because individuals without access to a flush toilet within the home are required to travel (typically by foot) a short distance in order to use the toilet, having a flush toilet in the home would decrease the minutes spent actively transporting oneself relative to those required to travel to the restroom. Additionally, while ownership cars/trucks and motorcycles/motorbikes is on the rise in Haiti, these items are still considered luxuries and are not ubiquitously owned within the country.[36,37]

Studies in higher income settings have supported an inverse relationship between SES and physical activity, but the significance of the association has been inconsistent.[113,143,144,146] In LMICs, a positive association between SES and physical activity has been displayed.[113] As this relationship did not hold true in this study, it is necessary to consider that Haiti is undergoing nutrition transition, which influences and is influenced by economic transition. Thus, the

relationship between SES and physical activity could be in flux, explaining why the findings here more closely resemble those found in a high-income setting.

The positive association between caregiver occupation in the market and adolescent physical activity outcomes could be the byproduct of the laborious nature of trading and selling in the market, as these workers carry their wares with them and actively transport themselves (*i.e.*, walk) through the streets of downtown Cap-Haïtien and the surrounding areas to sell their product. This suggests a protective effect of increased caregiver physical activity against adolescent physical inactivity. The relationship found in this analysis finding fits within the established literature, which has recognized parent/caregiver physical activity and general support for adolescent physical activity to be positively associated with adolescent physical activity.[143,145,146,317] This protective effect is not consistently significant throughout the literature, and has yet to be fully explored within a resource-poor setting like Haiti.[113,145,311,317] Further investigation is required within this context to understand the mechanism by which caregiver's increased physical activity influences the physical activity outcomes for adolescents in Cap-Haïtien.

In Chapter 3, expanded analyses of correlates of physical activity showed age and gender significantly associated with the models of physical activity outcomes, confirming the relevance and importance of these demographic predictors. The analyses in Chapter 3 expanded the models of physical activity outcomes to include variables related to the nutrition behaviors of Haitian adolescents. Nutrition and physical activity behaviors have been shown to cluster together and have been strongly associated with overall health outcomes in the literature.[311,333–335] Logically, nutrition and physical activity work synergistically, balancing energy intake and output, helping to achieve and maintain a healthy body composition. Adding variables to the previous model that

captured dietary diversity (a dietary diversity score [DDS]) and habits related to meals during the school day (*e.g.*, eating breakfast, bringing or buying a snack/meal) developed a more comprehensive model of physical activity outcomes.

Interestingly, DDS had a significant, positive relationship with physical activity outcomes. As adolescents' DDS increased, so did their odds of meeting the WHO REC. These findings suggest that increased dietary diversity adequately provides the energy intake required for partaking in MVPA. Dietary diversity is globally recognized as an indicator of diet quality and micronutrient intake.[199,200,376] Poor diet quality and micronutrient deficiency in childhood are related stunting, growth delay, and delayed motor development, which have been identified as potential predictors of adolescent motor skill mastery and adolescent physical activity.[65,323–332,377] Furthermore, malnutrition leads to osteomalacia, osteoporosis, bone fractures, and osteopenia, which present barriers to physical activity over the life course. The mechanism by which dietary diversity influences physical activity outcomes is its critical role in providing adequate nutrient consumption for the physiology and development of proper bone health in pubertal adolescence and motor skill mastery in late childhood and early adolescence .[330–332,340,341]

Research on adolescent physical activity has established a strong association between the nutrition, health outcomes, and socioeconomic status of children and adolescents. Though SES variables were not significant in the expanded models of physical activity outcomes in Chapter 3, their inclusion improved model fit. Additionally, SES moderated the relationship between DDS and whether an adolescent brought a snack/meal to school) and physical activity. When controlling for SES variables (*i.e.*, monthly household income, household access to electricity, household ownership of technological assets, household access to a flush toilet, caregiver education level, and caregiver occupation) both individually and as a group, the magnitude of the

influence of dietary diversity score on minutes of MVPA increased. The moderation by SES on the influence of DDS on physical activity suggests that higher education and economic capacity for purchasing foods both contribute to food security and a wider variety in foods available for consumption by the adolescent child, a relationship previously established in the literature.[376,378]

Common themes regarding high value of dietary diversity emerged in the focus group data presented in Chapter 4. Respondents commented that an unvaried diet and diets consisting of nutrient-poor foods were responsible for obesity and poor health outcomes. They also believed malnutrition to be a barrier for physical activity, as without adequate nutrition, they did not have sufficient energy to perform everyday activities. Furthermore, adolescent participants cited proper nutrition as enablers of physical activity, naming unprocessed or "natural" foods as more advantageous to health.

Body Composition

This study revealed an interesting and valuable understanding of the role of body composition in physical activity research within the Haitian context. The focus groups presented in Chapter 4 expanded the understanding of the values, beliefs, and behaviors related to body composition in Haitian adolescents. Most compelling was the cultural acceptance of overweight as both a positive status symbol and as a health benefit. As body adiposity has a potentially protective effect in a low-resource setting experiencing endemic undernutrition, positive value is placed on excess body weight, though to a limited degree. While overweight is recognized as a significant risk factor for poor health in a high-income setting, responses in these focus groups reflected a positive connotation for higher body fat. Negative health consequences associated with overweight in a high-resource setting are not applied to overweight individuals, but instead this category of excess body adiposity is bypassed, and all negative health outcomes are

associated with obesity. Indeed, separate terms were used to describe overweight individuals, differentiating them from excessively overweight or obese individuals. An overweight person was described as a *big* or *fat* person, and seen as healthy, with an ability to function normally in the everyday circumstance; individuals of this classification are considered well developed and strong, with a high capacity for executing strenuous activities like fetching water. However, an individual with extreme body adiposity is described as *obez* (the Haitian creole word for *obese*) or *boxy*, and these terms carry a negative connotation. This represents a unique barrier to public health intervention in the dual burden of malnutrition in Haiti, especially considering that overweight is medically considered as *pre-obesity*.[83] Programs designed to educate the public regarding body composition and to promote proper nutrition and physical activity will assuredly suffer lest they directly address this unique cultural perspective of fatness.

Previous research on body composition and physical activity has largely been operationalized as an examination of the effects of overweight/obesity and adiposity relative to a health body mass index.[113,143,144,146,379] Because this study was conducted in a resource-poor context with endemic undernutrition, these analyses deviated from the current body of literature by evaluating both extremes of body composition; to better understand physical activity within the context of the dual burden of malnutrition, it was necessary to evaluate the relationship between physical activity and low BAZ in addition to the relationship between physical activity and high BAZ.

Unique Haitian Perspectives

Other results presented in Chapter 4 provide a unique understanding of Haitian adolescents' beliefs regarding the health advantages of physical activity. It is widely accepted in exercise science and public health research that physical activity can promote healthy flexibility

and circulation.[380,381] Haitian adolescents generally agree with this sentiment, but hold a differing perspective regarding the mechanism by which this occurs. The phrases *relaxing the body* and *releasing the veins* were used to describe the physiological benefits of exercise and physical activity. Physical activity is believed to relax the muscles, stretching and lengthening them, which ultimately promotes agility and flexibility. Physical activity also allows the veins to "release"—meaning that they open wider or expand—which promotes blood flow and can help prevent heart attack or stroke. However, the participants described the role of the veins as the most important aspect of circulatory health, with lesser importance given to the heart's role in cardiovascular health. Both concepts suggested high value is placed on flexibility and proper blood flow for adolescent growth and development as well as maintenance of health into old age. These unique terms for healthy flexibility and circulation indicate belief in a direct link between physical activity and cardiovascular health. It will be important for future public health programs to work within these cultural beliefs, educating this group about the benefits of physical activity while using culturally sensitive and appropriate terminology.

Finally, of greatest importance for physical activity intervention/promotion research in Haiti, the focus groups revealed that adolescent perceptions of barriers to physical activity were seemingly surmountable without need for large-scale change or use of resources. Adolescents believed barriers to primarily stem from a lack of structured opportunity of physical activity, including a lack of equipment and space for conducting activity. Providing organized physical activities through the schools, accompanied with the appropriate equipment, would directly overcome multiple barriers at once—this was even a direct request from the students that arose in multiple focus groups. As limited space can be an issue, scheduling, reserving, and coordinating safe transportation to an open area for physical activity would simply need to factor

into the planning and execution of structured physical activity intervention programs. Furthermore, interventional programs of this nature could be tailored to address the gender disparities in physical activity outcomes, giving special focus to equal inclusion of both boys and girls.

5.2. Limitations & Strengths

5.2.1 Limitations

The cross-sectional design of this study limits conclusions regarding the cause-and -effect relationships, including the direction of the associations observed (the role of independent and dependent variables). Furthermore, there is the possibility of unmeasured confounding variables, which may influence or explain some of the observed relationships. The correlates of physical activity provided here could change within a larger sample population, and the possibility of committing a Type II error in the model cannot be excluded. Additionally, the small sample size limits the number of variables used in the model, thus potential over-fitting of the model may occur. However, these models are not presented for predictive purposes. Rather, this study was meant to provide the first analyses of correlates of physical activity, exploring trends and presenting preliminary data for larger studies that more rigorously and systematically identify factors related to physical activity.

The findings presented here deviate from previous analyses in that a significant relationship between adolescents' physical activity and certain common predictors of physical activity were not found. For example, adolescent overweight/obesity status and caregiver overweight/obesity status not have significant associations with meeting the WHO REC. Caregiver gender was only significantly associated with self-reported leisure-time activity domain but did not remain significant in the final model of leisure-time activity meeting the

WHO REC. Caregiver education level also did not have a significant association with physical activity outcomes. This could be explained by the lack of variation in the sample caused by bias due to the cross-sectional nature of the study or small sample size; exactly half of the caregiver population was overweight or obese, most respondents were female, and the majority had not completed primary school or did not receive further education at the conclusion of primary school. While these indicators have varied significance in developed countries, their application may not be as relevant in a low-resource context in LMICs, where cultural norms around education and gender roles differ.[144,317] But the influence of a limited sample size cannot be ignored.

Another limitation in this study was related to the devices used for the objectively assessed physical activity. The accelerometry devices used for the study were selected on criteria related to funding and availability. The uniaxial nature of the ActiGraph GT1M activity monitors has been shown to be equally reliable as triaxial accelerometers in assessment of physical activity among adolescents under free-living conditions; thus the uniaxial nature of the devices was not considered a limitation.[382] However, triaxial units are considered state of the art and better for capturing raw data. Furthermore, due to the age of the devices used, many malfunctioned in the field and participants were lost to corrupted data, greatly diminishing the sample size. Finally, the GT1M units are not water resistant. The inability to measure physical activity during swimming or bathing likely means total activity was underestimated, as these are periods of activity undocumented due to the water-sensitive nature of the accelerometer devices.

As the focus groups were limited to a single contact point, it was difficult to fully explore certain health-related topics. Generalizability is also limited, as the focus group numbers were small, qualitative analyses cannot be generalized to a wider population in same manner as

quantitative analyses. The focus groups were translated from Haitian Creole to English, and so cultural differences in language, inflection, idioms, or nuances of meaning may be lost. This, as well as possible acculturation of meaning, can influence interpretation.

5.2.2 Strengths

A marked strength of the study is the "triangulation" of physical activity data collected; self-reported physical activity behaviors from the surveys were compared with the objectively assessed accelerometry data, and the focus groups provided a loosely structured, open-ended assessment of physical activity behaviors. The comparison of these data collection methodologies is the first of its kind in this context, providing justification for both self-report and accelerometer assessments in future research. It also provides important baseline understanding of these behaviors, as this data has heretofore been unavailable for this population.

An additional strength of this study arises from the rigorous training of study enumerators, with ongoing contact between enumerators and study coordinators, providing an opportunity to address any potential issues as they arose. Furthermore, the same enumerators, anthropometric equipment, and accelerometer units were used a both data collection sites, providing a standardization of study protocol. Furthermore, all data management and analysis were centrally conducted, providing consistency in data handling and interpretation.

5.3 Implications for Future Study

The findings in the present study are consistent with the current body of literature, with deviations likely attributable to the evaluation of a different context (*i.e.*, a resource-poor urban environment in an LMIC). Future research is necessary to further evaluate physical activity in Haitian adolescents and other age groups—its predictors, cultural norms, and protective benefits are largely still unknown in this context. However, further evaluation should be conducted within

the lens of this study's findings, as they suggest that policy and environmental interventions are best applied to younger, female adolescents in Haiti.

5.3.1 Lessons Learned for the Next Steps

If this study were to be implemented again, lessons learned include the following. First and foremost, the study would be conducted with a larger sample size to improve statistical power, increase accuracy of mean values, identify any outliers potentially skewing the data, and decrease the potential margin of error. It would also allow for larger participation numbers in the focus groups, allowing further exploration into emergent themes until saturation was reached. Next, different equipment would be employed. Newer technology has led to the improved accuracy of accelerometers; a triaxial unit would better capture raw movement, and some newer triaxial units are water resistant. Furthermore, this project originally aimed to incorporate an analysis of GPS data into the accelerometry study. However, due to issues with equipment and lack of electricity for charging units while in-country, too many problems arose for inclusion of that data in this analysis. Newer accelerometry units contain GPS monitors, eliminating the need for a second device or daily access to electricity.

5.3.2 Designing the Next Steps

Although this dissertation focused on adolescents, future study could also include children over the age of 5, as considerable research is available for this population, and targeting this group could also mitigate early origins of poor health outcomes, instilling lifelong healthy habits. Furthermore, a school-based intervention aimed at an expanded age group would eliminate possible aversion to participation from parents and caregivers with multiple children, as they would not have to coordinate multiple commuting and care schedules for their children.

Secondly, all three elements of the study included in this dissertation provide evidence for a link between gender and physical activity outcomes. Time spent in MVPA and meeting the WHO recommendation for physical activity in adolescents were consistently related to adolescent gender and adolescent age. Focus groups revealed differences in activity identified to gender norms related to chores and utilitarian activity. A 20-country surveillance study assessing physical activity in high-, medium-, and low-income countries showed men to have higher rates of physical activity than women.[383] Further exploring these differences in children, adolescents, and adults could hold important clues to valuable points of intervention for public health research into the dual burden.

Finally, the ideal next steps would involve expanded focus groups, a subsequent pilot intervention study, and in-depth one-on-one interviews with study participants. First, more focus groups would be conducted to more fully explore the themes that emerged in this study. Focus groups would also be used to help shape the design and implementation of a school-based physical activity intervention. Focus groups would be expanded to include parents, teachers, and school administrators. One-on-one interviews with potential adolescent participants would provide the opportunity for a deeper understanding of the concepts presented in Chapter 4. Mental mapping methodologies employed in the interviews would also provide insights into the adolescents' physical activity behaviors in relationship to their home and school environments.

Then, a small pilot program, conducted at the two primary schools participating in this study, would take place. Participants in this intervention would participate in focus groups and in-depth interviews to provide ongoing evaluation of program acceptance. Preferably, the intervention would provide contact with the students on multiple weekdays, with the longest point of contact occurring on Fridays after early dismissal. The program would include

supplemental nutrition, likely *Vita Mamba* produced by MFK Haiti, a school snack providing supplemental energy, protein, fatty acids, and other micronutrients essential for child and adolescent growth and development.[384] Finally, the intervention would be carefully tailored to address the cultural norms and gender disparities identified in the course of this current study.

5.3.3 Policy & Surveillance Implications

As previously stated in Chapter 2, Haiti currently lacks any formal physical activity policy or surveillance systems. The Global Observatory of Physical activity, which monitors publishes country cards detailing policy, research, and surveillance indicators for physical activity, reports that there are currently zero national surveys, active researchers, publishing groups, or monitoring systems in place within Haiti.[300] This is best attributed to Haiti's early position in both the nutrition and physical activity transitions, and the country's history of pervasive undernutrition. However, as indicators of these transitions are already present within Haiti's health and demographic data, the need for formal policy and surveillance will likely become increasingly necessary. The following details suggested goals for research, policy, and surveillance efforts within Haiti.

Currently, Haiti has numerous formal policies and programs concerning nutrition, as detailed in Section 1.6.1. In addition to nutrition policies, implementing formal national policies for physical activity in Haiti will provide a unified structure upon which physical activity research and surveillance can function within the context of the nutrition and physical activity transitions. A formal plan or strategy for physical activity should focus upon meaningful physical activity, with special attention paid to transport physical activity and school-based interventions. A major barrier to physical activity in Haiti is the built environment, and as such, policy concerning to improve urban- level prevalence of "complete streets" will reduce barriers to

active transportation, making the built environment activity friendly (*i.e.*, safe and accessible space for active transport). This also includes urban-level community-wide polices and that inform and support community-based physical activity programming through reduction in environmental (social/cultural) and structural barriers to active living. This in turn could lead to policies regarding transportation plans that promote walking and bicycling as preferred methods of transportation. In schools, policy should focus on increasing the frequency of and active time in school-based physical education classes, school-based sports, and after school sports programming. This includes policies requiring daily physical education and physical activity. Furthermore, increasing access to physical activity training for teachers, academic administrators, and health professionals working in schools would provide the knowledge and cultural support for physical activity promotion.

National policies that increased the number of government funding opportunities related to physical activity promotion would provide the basis upon which physical activity research could develop. Research goals should include increasing the number of studies examining the association between physical inactivity, sedentary behaviors, and common diet-related non-communicable diseases within Haiti. This goal would be accomplished through an initial priority given to studies that investigate determinants of physical activity via cross-sectional design, and then later longitudinal, cohort designs associating determinants and long-term health outcomes. After baseline data has been collected and surveillance systems are in place, funding priority should shift to support intervention studies that promote evidence-based, culturally sensitive, and sustainable programs. Papers and publishing groups with a primary investigator or co-lead author whose primary affiliation is within Haiti should be prioritized throughout all phases of research development.

Surveillance would inform research comparing physical activity behavioral and health indicators for comparing Haiti to other countries, both globally and regionally. Surveillance goals should include adoption of country-level physical activity and sedentary behaviors within EMMUS-DHS surveys. Ongoing surveillance of physical activity and sedentary behaviors should prioritize data availability and access for the purposes of driving evidenced-based research goals, funding priorities, and policy implementation.

5.4 Conclusions

Indicators of the nutritional transition are becoming increasingly prevalent in Haiti. Data for the study of Haiti's placement within the physical activity transition have heretofore been unavailable, as study of physical activity in Haiti is in its infancy. This exploratory study is the first of its kind, directly examining physical activity measurement methodologies, identifying initial correlates, and evaluating context-based values, beliefs, and behaviors to understand the current status of physical activity within Haitian adolescents.

Due to the exploratory, cross-sectional nature of this study, cause-and-effect statements cannot be made regarding physical activity and its determinants. However, the results presented here can serve as a guide for the next steps in researching physical activity, the nutrition and physical activity transitions, and the dual burden of malnutrition in Haiti. The research conducted for this dissertation suggests that further physical activity research and promotion for adolescents is both necessary and welcomed within the study population. Primarily, the data suggests that younger adolescents and female adolescents experience the poorest physical activity outcomes. As such, future investigation into monitoring these groups and understanding the social and cultural determinants of their physical activity behaviors is warranted.

Additionally, this study suggests the relationship between dietary diversity and physical activity to be robust. Incorporating nutritional elements into physical activity programming could benefit intervention work, as this population has historically experienced widespread undernutrition and food insecurity. As such, context-relevant programs should balance energy intake with physical activity via nutritional supplementation. This approach is likely the most appropriate for addressing both extremes of malnutrition and body composition within the context of changing food environments and physical activity patterns as related to the nutrition transition.

Finally, this study has highlighted the need for formal physical activity related policy, research, and surveillance. Understanding Haiti's status within the nutrition and physical activity transitions will rely on the actualization of these efforts. To date, these systems are not in place within the country, but will likely be of increasing necessity in mitigating the negative economic and health effects of the dual burden of malnutrition.

This dissertation study represents the first step in a long-term research agenda. The overall goal of this research plan consists of a) characterizing the link between the emergence of the dual burden of malnutrition and its risk factors in Haiti and other LMICs, b) providing rationale for the early adoption of policy and program development for school-based physical activity, nutrition, and other types of assistance programming in Haiti and other LMICs, and c) improving the surveillance, prevention, and control of malnutrition problems within Haiti and other LMICs. The issues and challenges are vast and complex; however, ongoing research, policy, and surveillance efforts offer promise, not only for the future health outcomes of Haitian adolescents, but for all of Haiti.

References/Bibliography/Works Cited

1. FAO. *The Double Burden of Malnutrition: Case Studies from Six Developing Countries.* Rome; 2006.
2. Tzioumis E, Adair LS. Childhood dual burden of under- and overnutrition in low- and middle-income countries: a critical review. *Food Nutr Bull*. 2014;35(2):230-243. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4313560&tool=pmcentrez&rendertype=abstract.
3. Varela-Silva MI, Dickinson F, Wilson H, Azcorra H, Griffiths PL, Bogin B. The nutritional dual-burden in developing countries--how is it assessed and what are the health implications? *Coll Antropol*. 2012;36(1):39-45. http://www.ncbi.nlm.nih.gov/pubmed/22816196.
4. Sunguya B, Ong K, Dhakal S, Mlunde L, Yasuoka J. *Nutrition Transition in Low and Middle-Income Countries : How Nutrition Policies Respond to the Dual Burden of Obesity and Undernutrition - a Systematic Review Protocol*.; 2014.
5. Sunguya BF, Ong KI, Dhakal S, et al. Strong nutrition governance is a key to addressing nutrition transition in low and middle-income countries: review of countries' nutrition policies. *Nutr J*. 2014;13(1):65. doi:10.1186/1475-2891-13-65
6. Popkin B. The nutrition transition: an overview of world patterns of change. *Nutr Rev*. 2004;62(Suppl 2):S140-S143. doi:10.1301/nr.2004.jul.S140
7. Popkin B. Nutritional Patterns and Transitions. *Popul Dev Rev*. 1993;19(1):138-157. doi:10.2307/2938388
8. Popkin B. The nutrition transition and obesity in the developing world. *J Nutr*. 2001;131(3):871S-873S.
9. Caballero B. A nutrition paradox--underweight and obesity in developing countries. *N Engl J Med*. 2005;352(15):1514-1516. doi:10.1056/NEJMp048310
10. Doak CM, Adair LS, Bentley M, Monteiro C, Popkin BM. The dual burden household and the nutrition transition paradox. *Int J Obes*. 2005;29(1):129-136. doi:10.1038/sj.ijo.0802824
11. Frenk J, Frejka T, Bobadilla J, et al. La transición epidemiológica en América Latina. *Boletín la Of Sanit Panam*. 1991;111(6):485-496.
12. Yusuf S, Reddy S, Ounpuu S, Anand S. Global burden of cardiovascular diseases: Part 1: General considerations, the epidemiologic transition, risk factors, and impact of urbanization. *Circulation*. 2001;104(22):2746-2753. doi:10.1161/hc4601.099487
13. Lopez, Mathers, Ezzati, Jamison, Murray. *Global Burden of Disease and Risk Factors*. (Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJ, eds.). Washington (DC): World Bank; 2006. http://www.ncbi.nlm.nih.gov/books/NBK11812/.
14. Popkin B, Adair L, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. *Nutr Rev*. 2012;70(1):3-21. doi:10.1111/j.1753-4887.2011.00456.x
15. IFPRI. *2014 Global Hunger Index: The Challenge of Hidden Hunger*.; 2014. doi:10.2499/9780896299627
16. FAO. *Globalization of Food Systems in Developing Countries: Impact on Food Security and Nutrition*. Rome; 2004. doi:17-05-2011
17. Geels FW. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Res Policy*. 2002;31(8-9):1257-1274. doi:10.1016/S0048-7333(02)00062-8
18. Bell AC, Ge K, Popkin BM. Weight gain and its predictors in Chinese adults. *Int J Obes Relat Metab Disord*. 2001;25(7):1079-1086. doi:10.1038/sj.ijo.0801651
19. Bell AC, Ge K, Popkin BM. The road to obesity or the path to prevention: motorized transportation and obesity in China. *Obes Res*. 2002;10(4):277-283. doi:10.1038/oby.2002.38
20. Monda KL, Adair LS, Zhai F, Popkin BM. Longitudinal relationships between occupational and domestic physical activity patterns and body weight in China. *Eur J Clin Nutr*. 2008;62(11):1318-1325. doi:10.1038/sj.ejcn.1602849
21. Frenk J, Bobadilla J, Sepúlveda J, Lopez Cervantes M. Health transition in middle-income countries: new challenges for health care. *Health Policy Plan*. 1989;4(1):29-39. http://heapol.oxfordjournals.org/content/4/1/29.short.
22. Lee J, Houser RF, Must A, De Fulladolsa PP, Bermudez OI. Disentangling nutritional factors and household characteristics related to child stunting and maternal overweight in Guatemala. *Econ Hum Biol*. 2010;8(2):188-196. doi:10.1016/j.ehb.2010.05.014
23. Rivera JA, Barquera S, González-Cossío T, Olaiz G, Sepúlveda J. Nutrition transition in Mexico and in other Latin American countries. *Nutr Rev*. 2004;62(7 Pt 2):S149-S157. doi:10.1301/nr.2004.jul.S149

24. Barquera S, Peterson KE, Must A, et al. Coexistence of maternal central adiposity and child stunting in Mexico. *Int J Obes*. 2007;31(4):601-607. doi:10.1038/sj.ijo.0803529
25. Barros FC, Victora CG, Vaughan JP, et al. The epidemiological transition in maternal and child health in a Brazilian city, 1982-93: A comparison of two population-based cohorts. *Paediatr Perinat Epidemiol*. 2001;15(1):4-11. doi:10.1046/j.1365-3016.2001.00320.x
26. Chopra M, Sanders D. From apartheid to globalisation: health and social change in South Africa. *Hygiea Int*. 2004;4(1):153-174. doi:10.3384/hygiea.1403-8668.0441153
27. Doak CM, Adair LS, Monteiro C, Popkin BM. Overweight and underweight coexist within households in Brazil, China and Russia. *J Nutr*. 2000;130(12):2965-2971.
28. Garrett JL, Ruel MT. Stunted child growth overweight mother pairs: prevalence and association with economic development and urbanization. *Food Nutr Bull*. 2005;26(2):209-221.
29. Garrett J, Ruel MT. Garrett, J., & Ruel, M. T. (2005). The coexistence of child undernutrition and maternal overweight: Prevalence, hypotheses, and programme and policy implications. Maternal and Child Nutrition, 1(3), 185–196. http://doi.org/10.1111/j.1740-8709.2005.00034.x. *Matern Child Nutr*. 2005;1(3):185-196. doi:10.1111/j.1740-8709.2005.00034.x
30. Khan NC, Khoi HH. Double burden of malnutrition: the Vietnamese perspective. *Asia Pac J Clin Nutr*. 2008;17(Suppl 1):116-118.
31. Khor GL, Sharif ZM. Dual forms of malnutrition in the same households in Malaysia - A case study among Malay rural households. *Asia Pac J Clin Nutr*. 2003;12(4):427-437.
32. Morshed AB, Becker H V., Delnatus JR, Wolff PB, Iannotti LL. Early nutrition transition in Haiti: linking the food environment to overweight status in school-aged children. *Public Health Nutr*. 2016.
33. Raphaël D, Delisle H, Vilgrain C. Households with undernourished children and overweight mothers: Is this a concern for Haiti? *Ecol Food Nutr*. 2005;44(2):147-165. doi:10.1080/03670240590923550
34. WHO. Overweight (body mass index >= 25) (age-standardized estimate): Data by country. Global Health Observatory Data Repository. http://apps.who.int/gho/data/node.main.A897A?lang=en. Published 2015. Accessed September 6, 2015.
35. Uauy R, Kain J. The epidemiological transition: need to incorporate obesity prevention into nutrition programmes. *Public Health Nutr*. 2002;5(1A):223-229. doi:10.1079/PHN2001297
36. Cayemittes M, Placide MF, Mariko S, Barrère B, Sévère B, Alexandre C. *Enquete Mortalite, Morbidite et Utilisation Des Services (EMMUS IV)*.; 2007. http://dhsprogram.com/pubs/pdf/FR192/FR192.pdf.
37. Cayemittes M, Busangu MF, Bizimana JDD, et al. *Enquête Mortalité, Morbidité et Utilisation Des Services, EMMUS-V, Haïti, 2012*.; 2013. http://dhsprogram.com/publications/publication-FR273-DHS-Final-Reports.cfm.
38. MSPP, IHE, DHS, ICF. *Enquête Mortalité, Morbidité et Utilisation Des Services (EMMUS-VI) Indicateurs Clés*.; 2017. https://mspp.gouv.ht/site/downloads/rapport preliminaire emmus VI.pdf. Accessed September 16, 2018.
39. Mendez MA, Monteiro CA, Popkin BM. Overweight exceeds underweight among women in most developing countries. *Am J Clin Nutr*. 2005;81(714-721).
40. Draper C, de Villiers A, Lambert E, et al. HealthKick: A nutrition and physical activity intervention for primary schools in low-income settings for the prevention of diabetes in the Western Cape. *South African J Clin Nutr*. 2010;23(3):S31. http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L71007519%5Cnhttp://www.sajcn.com/index.php/SAJCN/article/download/476/581%5Cnhttp://rd8hp6du2b.search.serialssolutions.com?sid=EMBASE&issn=16070658&id=doi:&atitle=HealthKick:+A+nutritio.
41. Griffiths PL, Bentley ME. The nutrition transition is underway in India. *J Nutr*. 2001;131(10):2692-2700.
42. Larrea C, Freire W. Social inequality and child malnutrition in four Andean countries. *Rev Panam Salud Publica*. 2002;11:356-364. doi:10.1590/S1020-49892002000500010
43. WHO. *Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks*. Vol 87. Geneva; 2009. doi:10.2471/BLT.09.070565
44. Black RE, Allen LH, Bhutta Z a., et al. Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet*. 2008;371(9608):243-260. doi:10.1016/S0140-6736(07)61690-0
45. United Nations. *The Millennium Development Goals Report*.; 2015. doi:978-92-1-101320-7
46. de Onis M, Blossner M, Borghi E, Frongillo EA, Morris R. Underweight in 1990 and 2015. *J Am Med Assoc*. 2004;291(21):2600-2606.
47. WHO. Ending Malnutrition by 2020: An Agenda for Change in the Millennium. *Food Nutr Bull*. 2000;21:3-

88.
48. WHO. *WHO Child Growth Standards*. Geneva; 2006. doi:10.4067/S0370-41062009000400012
49. Black RE, Victora CG, Walker SP, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet*. 2013;382(9890):427-451. doi:10.1016/S0140-6736(13)60937-X
50. Nandy S, Svedberg P. The Composite Index of Anthropometric Failure (CIAF): An Alternative Indicator for Malnutrition in Young Children. In: Preedy VR, ed. *Handbook of Anthropometry: Physical Measures of Human Form in Health and Disease*. ; 2012:127-137. doi:10.1007/978-1-4419-1788-1
51. Waterlow JC. Some aspects of childhood malnutrition as a public health problem. *Br Med J*. 1974;4(5936):88-90. doi:10.1136/bmj.4.5936.88
52. WHO. *WHA Global Nutrition Targets 2025: Stunting Policy Brief*.; 2014. http://www.who.int/nutrition/topics/globaltargets_stunting_policybrief.pdf.
53. WHO. *Nutrition in Adolescence – Issues and Challenges for the Health Sector: Issues in Adolescent Health and Development*. Geneva; 2005. http://apps.who.int/iris/bitstream/10665/43342/1/9241593660_eng.pdf. Accessed March 27, 2017.
54. IOM. *Weight Gain During Pregnancy : Reexamining the Guidelines*. (Rasmussen KM, Yaktine AL, eds.). The National Academies Press; 2009. doi:10.1097/00006250-196901000-00025
55. Detsky a S, McLaughlin JR, Baker JP, et al. What is subjective global assessment of nutritional status? *JPEN J Parenter Enteral Nutr*. 1987;11(1):8-13. doi:10.1186/1757-2215-1-5
56. Prentice AM, Moore SE. Early programming of adult diseases in resource poor countries. *Arch Dis Child*. 2005;90(4):429-432. doi:10.1136/adc.2004.059030
57. Hales C, Barker D. The thrifty phenotype hypothesis. *Br Med Bull*. 2001;60(1):5-20. doi:10.1093/bmb/60.1.5
58. Sawaya AL, Sesso R, Florencio TM, Fernandes MT, Martins, Paula A. Association between chronic undernutrition and hypertension. *Matern Child Nutr*. 2005;1(3):155-163. doi:10.1111/j.1740-8709.2005.00033.x
59. Eriksson JG, Forsén T, Tuomilehto J, Winter PD, Osmond C, Barker DJP. Catch-up growth in childhood and death from coronary heart disease: longitudinal study. *Br Med J*. 1999;318(7181):427-431. doi:10.1136/bmj.318.7181.427
60. Victora CG, Adair L, Fall C, et al. Maternal and child undernutrition: consequences for adult health and human capital. *Lancet*. 2008;371(9609):340-357. doi:10.1016/S0140-6736(07)61692-4
61. Lindsay RS, Bennett PH. Type 2 diabetes: the thrifty phenotype- an overview. *Br Med Bull*. 2001;60(1):21–32. http://bmb.oxfordjournals.org/content/60/1.
62. Sawaya A, Roberts S. Stunting and future risk of obesity: principal physiological mechanisms. *Cad saude publica / Minist da Saude, Fund Oswaldo Cruz, Esc Nac Saude Publica*. 2003;19 Suppl 1(Suppl 1):S21-S28. doi:10.1590/S0102-311X2003000700003
63. Wells JCK. Maternal capital and the metabolic ghetto: an evolutionary perspective on the transgenerational basis of health inequalities. *Am J Hum Biol*. 2010;22(1):1-17. doi:10.1002/ajhb.20994
64. Wright CM, Parker L, Lamont D, Craft AW. Implications of childhood obesity for adult health: findings from thousand families cohort study. *Br Med J*. 2001;323(7324):1280-1284. doi:10.1136/bmj.323.7324.1280
65. Stewart CP, Iannotti L, Dewey KG, Michaelsen KF, Onyango AW. Contextualising complementary feeding in a broader framework for stunting prevention. *Matern Child Nutr*. 2013;9(S2):27-45. doi:10.1111/mcn.12088
66. Sawaya AL, Martins P, Hoffman D, Roberts SB. The link between childhood undernutrition and risk of chronic diseases in adulthood: a case study of Brazil. *Nutr Rev*. 2003;61(5 Pt 1):168-175. doi:10.1301/nr.2003.may.168-175
67. Martins P a., Hoffman DJ, Fernandes MTB, et al. Stunted children gain less lean body mass and more fat mass than their non-stunted counterparts: a prospective study. *Br J Nutr*. 2004;92(05):819. doi:10.1079/BJN20041274
68. Popkin B, Richards MK, Montiero CA. Community and international nutrition stunting is associated with overweight in children of four nations that are undergoing the nutrition transition. *J Nutr*. 1996;126(12):3009-3016.
69. Teo K, Chow CK, Vaz M, Rangarajan S, Yusuf S. The Prospective Urban Rural Epidemiology (PURE) study: examining the impact of societal influences on chronic noncommunicable diseases in low-, middle-, and high-income countries. *Am Heart J*. 2009;158(1):1-7.e1. doi:10.1016/j.ahj.2009.04.019

70. WHO. Obesity and overweight fact sheet. Media Centre Publication. http://www.who.int/mediacentre/factsheets/fs311/en/#. Published 2015. Accessed September 6, 2015.
71. WHO. *Obesity: Preventing and Managing the Global Epidemic*. Vol 894. Geneva; 2000. http://www.ncbi.nlm.nih.gov/pubmed/11234459.
72. WHO. Global status report on noncommunicable diseases 2014. *World Health*. 2014:176. doi:ISBN 9789241564854
73. Must A, Strauss RS. Risks and consequences of childhood and adolescent obesity. *Int J Obes Relat Metab Disord*. 1999;23(Suppl 2):S2-S11. doi:10.1038/sj/ijo/0800852
74. Neumark-Sztainer D. The weight dilemma: a range of philosophical perspectives. *Int J Obes Relat Metab Disord*. 1999;23((Suppl 2)):S31-S37. doi:10.1038/sj/ijo/0800857
75. Ng M, Fleming T, Robinson M, et al. 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*. 2014;384(9945):766-781. doi:10.1016/S0140-6736(14)60460-8
76. Sucharda P. Clinical significance of the quantification of obesity: The Quetelet Index and its use. *Cas Lek Ces*. 1989;128(33):1040-1043.
77. Kuczmarski RJ. Chapter 2 What is Obesity? Definitions Matter. In: *Handbook of Obesity Prevention*. Springer; 2007:25-44.
78. WHO. AnthroPlus for Personal Computers Manual: Software for assessing growth of the world's children. 2007:1-45. http://www.who.int/growthref/tools/en/.
79. WHO. The Z-score or standard deviation classification system. WHO. http://www.who.int/nutgrowthdb/about/introduction/en/index4.html. Published 2010. Accessed October 16, 2018.
80. WHO. WHO Application tools: Growth Reference 5-19 years. WHO. https://www.who.int/growthref/tools/en/. Published 2018. Accessed October 16, 2018.
81. Gibson RS. *Principles of Nutritional Assessment*. Oxford; 2005.
82. Withers R, Laforgia J, Pillans R, et al. Comparisons of two-, three-, and four-compartment models of body composition analysis in men and women. *J Appl Physiol*. 1998;85(1):238-245.
83. Philip W, James T, Lobstein T. BMI Screening and Surveillance: An International Perspective. *Pediatrics*. 2009. doi:10.1542/peds.2008-3586G
84. Barba C, Cavalli-Sforza T, Cutter J, et al. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*. 2004;363(9403):157-163. doi:10.1016/S0140-6736(03)15268-3
85. WHO, IASO, IOTF. *The Asia-Pacific Perspective: Redefining Obesity and Its Treatment*. Melbourne, Australia; 2000.
86. Popkin B. Global changes in diet and activity patterns as drivers of the nutrition transition. *Nestle Nutr Inst Workshop Ser*. 2009;63:1-10; discussion 10-14, 259-268. doi:10.1159/000209967
87. WFP. *Haiti 2010-2013: Working Towards Sustainable Solutions*. Port-au-Prince; 2013.
88. DHS. *Haïti: 2012 Mortality, Morbidity, and Service Utilization Survey Key Findings*.; 2013. http://dhsprogram.com/publications/publication-SR199-Summary-Reports-Key-Findings.cfm.
89. Shetty P. Impact of globalization on food and agriculture from the farm to the plate. In: *Impacts of Globalization on Agricultural Production and Marketing with Focus on Food Quality*. Tokyo, Japan; 2003:22-24.
90. Popkin B. Global context of obesity. In: Kumanyika S, Brownson RC, eds. *Handbook of Obesity Prevention: A Resource for Health Professionals*. New York: Springer; 2007:227-238.
91. Coca-Cola Company. The Coca-Cola System: Bottling Investment Groups (BIG) Global Footprint. http://www.coca-colacompany.com/our-company/the-coca-cola-system. Published 2015.
92. McDonald's. Discover McDonald's Around the Globe. http://www.aboutmcdonalds.com/mcd/country/map.html. Published 2016. Accessed June 1, 2016.
93. Coca-Cola Company. Coca-Cola in Haiti: The Haiti Hope Project. Stories. http://www.coca-colacompany.com/stories/coca-cola-in-haiti. Published 2012. Accessed November 15, 2015.
94. WHO. *Haiti: WHO Statistical Profile*.; 2015. http://www.who.int/gho/countries/hti.pdf?ua=1. Accessed May 23, 2016.
95. Chopra M. Globalization , urbanization and nutritional change South Africa case study. *FAO Glob food Syst Dev Ctries impact food Secur Nutr*. 2003;FAO Food a(No. 83):119-133.
96. Popkin B. Global nutrition dynamics: the world is shifting rapidly toward a diet linked with

noncommunicable diseases. *Am J Clin Nutr*. 2006;84(2):289-298. doi:84/2/289 [pii]
97. Rivera JA, Barquera S, Campirano F, Campos I, Safdie M, Tovar V. Epidemiological and nutritional transition in Mexico: rapid increase of non-communicable chronic diseases and obesity. *Public Health Nutr*. 2002;5(1A):113-122. doi:10.1079/PHN2001282
98. Uauy R, Vio F. Health and nutrition transition in developing countries: the case of Chile. *Nation's Nutr*. 2007;2000:117-128.
99. Mutatkar RK. Public health problems of urbanization. *Soc Sci Med*. 1995;41(7):977-981. doi:10.1016/0277-9536(94)00398-D
100. Reardon T, Berdegué JA. The Rapid Rise of Supermarkets in Latin America: Challenges and Opportunities for Development. *Dev Policy Rev*. 2002;20(4):371-388.
101. Reardon T, Barrett CB, Berdegué JA, Swinnen JFM. Agrifood Industry Transformation & Small Farmers in Developing Countries. *World Dev*. 2009;37(11):1717-1727. doi:10.1016/j.worlddev.2008.08.023
102. CIA. Country overview of Haiti. The World Factbook. https://www.cia.gov/library/publications/the-world-factbook/geos/ha.html. Published 2016. Accessed February 2, 2016.
103. Popkin B. The nutrition transition in low-income countries: an emerging crisis. *Nutr Rev*. 1994;52(9):285-298. doi:7984344
104. Lobstein T, Baur L a, Uauy R. Obesity in children and young people: A crisis in public health. *Obes Rev*. 2004;5(Suppl 1):4-104. doi:10.1111/j.1467-789X.2004.00133.x
105. Evans JP. *Environmental Governance*. 1st ed. New York, NY.: Routledge; 2012.
106. Omran AR. The epidemiologic transition: a theory of the epidemiology of population change. *Milbank Mem Fund Q*. 1971;49(4 Part 1):509-538. doi:10.1126/science.58.1509.437-a
107. Katzmarzyk PT, Mason C. The Physical Actvity Transition. *J Phys Act Heal*. 2009;6:269-280.
108. Caballero, B., & Popkin BM. *The Nutrition Transition: Diet and Disease in the Developing World*. (Caballero B, Popkin BM, eds.).; 2002.
109. Albala C, Vio F. Epidemiological transition in Latin America: the case of Chile. *Public Health*. 1995;109(6):431-442.
110. Yoshio Laing B, Mangione CM, Tseng C-H, et al. Effectiveness of a smartphone application for weight loss compared to usual care in overweight primary care patients: A randomized controlled trial. *Ann Intern Med*. 2014;161(10 Suppl):S5-S12. doi:10.7326/M13-3005
111. Smith J, Morgan P, Plotnikoff R, et al. Smart-phone obesity prevention trial for adolescent boys in low-income communities: The ATLAS RCT. *Pediatrics*. 2014;134(3):e723-731. doi:10.1542/peds.2014-1012
112. Malina RM, Little BB. Physical activity: The present in the context of the past. *Am J Hum Biol*. 2008;20(4):373-391. doi:10.1002/ajhb.20772
113. Bauman AE, Reis RS, Sallis JF, et al. Correlates of physical activity: Why are some people physically active and others not? *Lancet*. 2012;380(9838):258-271. doi:10.1016/S0140-6736(12)60735-1
114. Hawkes C. The Worldwide Battle Against Soft Drinks in Schools. *AMEPRE*. 2010;38(4):457-461. doi:10.1016/j.amepre.2010.01.011
115. Barquera S, Campirano F, Bonvecchio A, Hernández-Barrera L, Rivera J a, Popkin BM. Caloric beverage consumption patterns in Mexican children. *Nutr J*. 2010;9(1):47. doi:10.1186/1475-2891-9-47
116. Hawkes C. *Marketing Activities of Global Soft Drink and Fast Food Companies in Emerging Markets: A Review.*; 2002.
117. Oxfam Mexico. *La Ley "Anti Obesidad" Tan Sólo Estrategia de Las Empresas: Consumidores.*; 2010.
118. Urban LE, Dallal GE, Robinson LM, Ausman LM, Saltzman E, Roberts SB. The Accuracy of Stated Energy Contents of Reduced-Energy, Commercially Prepared Foods. *J Am Diet Assoc*. 2010;110(1):116-123. doi:10.1016/j.jada.2009.10.003
119. McGinnis J, Gootman J, Kraak V. *Food Marketing to Children and Youth: Threat or Opportunity:* Washington (DC): National Academies Press; 2006.
120. Hancox RJ, Poulton R. Watching television is associated with childhood obesity: but is it clinically important? *Int J Obes*. 2006;30(1):171-175. doi:10.1038/sj.ijo.0803071
121. Hastings G, Mcdermott L, Angus K, Stead M, Thomson S. *The Extent, Nature, and Effects of Food Promotion to Children: A Review of the Evidence*.; 2006. https://www.sfu.ca/cmns/courses/2008/801/Spring2008/ClassFolders/Iwase_Masa/SelectedTopicMaterials/Hastings_paper_marketing.pdf. Accessed June 1, 2016.
122. Hastings G, Stead M, Mcdermott L, et al. *REVIEW OF RESEARCH ON THE EFFECTS OF FOOD PROMOTION TO CHILDREN Final Report Prepared for the Food Standards Agency EXECUTIVE*

SUMMARY: Does Food Promotion Influence 1 Children? A Systematic Review Of The Evidence MANAGEMENT SUMMARY 4.; 2003. http://www.csm.strath.ac.uk. Accessed June 1, 2016.
123. Klesges RC, Shelton ML, Klesges LM. Effects of Television on Metabolic Rate: Potential Implications For Childhood Obesity. *Pediatrics*. 1993;91(2):281-286. http://pediatrics.aappublications.org/cgi/content/abstract/91/2/281.
124. Dietz H, Gortmaker L. Do We Fatten Out Our Children at the Television Set? Obesity Television Viewing in Children and Adolescents. *Pediatrics*. 1985;75(5):807-812.
125. Chou S-Y, Rashad I, Grossman M. Fast-Food Restaurant Advertising on Television and Its Influence on Childhood Obesity. *J Law Econ*. 2008;51(4):599-618. doi:10.3386/w18640
126. Mayer CE. Kraft to Curb Snack-Food Advertising: Move to Phase out Ads Aimed at Kids Under 12. *Washington Post*. http://healthylivingforlife.org/_web-assets/pdfs/Kraft to Curb Snack- article.pdf. Published January 12, 2005.
127. Merca2.0. PepsiCo dice ¡Salud! *Mercadotecnia publicided medios Editorial*. http://www.merca20.com/pepsico-dice-salud/. Published 2007.
128. Gómez L, Jacoby Iii E, Ibarra L, et al. Sponsorship of physical activity programs by the sweetened beverages industry: public health or public relations? *Rev Saúde Pública*. 2011;45(2).
129. El Tiempo. La ciclovía tendrá puntos especiales de hidratación, comenzarán a funcionar este domingo. *Editorial*. July 15, 2010.
130. Hawkes C. Regulating and litigating in the public interest. Regulating food marketing to young people worldwide: Trends and policy drivers. *Am J Public Health*. 2007;97(11):1962-1973. doi:10.2105/AJPH.2006.101162
131. Lock K, Stuckler D, Charlesworth K, McKee M. Potential causes and health effects of rising global food prices. *Br J Med*. 2009;3339:b2403.
132. Gerbens-Leenes PW, Nonhebel S, Krol MS. Food consumption patterns and economic growth. Increasing affluence and the use of natural resources. *Appetite*. 2010;55:597-608. doi:10.1016/j.appet.2010.09.013
133. Nugent R. Food and agriculture policy: Issues related to prevention of noncommunicable diseases. *Food Nutr Bull*. 2004;25(2). http://fnb.sagepub.com/content/25/2/200.full.pdf. Accessed June 1, 2016.
134. FEWS NET. *Haiti: Staple Food Market Fundamentals*.; 2018. http://www.fews.net. Accessed September 23, 2018.
135. Fuller-Wimbush D, Fils-Aimé C. *Feed the Future Investment in Haiti: Implications for Sustainable Food Security and Poverty Reduction*.; 2014.
136. FAO. FAO's food price index revisited. *Food Outlook*. 2013;November:69-74.
137. Brownson RC, Baker EA, Housemann RA, Brennan LK, Bacak SJ. Environmental and policy determinants of physical activity in the United States. *Am J Public Health*. 2001;91(12):1995-2003. doi:10.2105/AJPH.91.12.1995
138. Harris JK, Lecy J, Hipp JA, Brownson RC, Parra DC. Mapping the development of research on physical activity and the built environment. *Prev Med (Baltim)*. 2013;57(5):533-540. doi:10.1016/j.ypmed.2013.07.005
139. Handy S. *Critical Assessment of the Literature on the Relationships Among Transportation, Land Use, and Physical Activity*.; 2004. doi:Cited By (since 1996) 31\rExport Date 27 September 2011
140. Gordon-Larsen P. Inequality in the Built Environment Underlies Key Health Disparities in Physical Activity and Obesity. *Pediatrics*. 2006;117(2):417-424. doi:10.1542/peds.2005-0058
141. Handy SL, Boarnet MG, Ewing R, Killingsworth RE. How the built environment affects physical activity: Views from urban planning. *Am J Prev Med*. 2002;23(2 SUPPL. 1):64-73. doi:10.1016/S0749-3797(02)00475-0
142. WHO. Prevalence of insufficient physical activity. WHO: Global Health Observatory. http://www.who.int/gho/ncd/risk_factors/physical_activity_text/en/. Published 2015. Accessed July 7, 2016.
143. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity. *Med Sci Sport Exerc*. 2000;32(5):963-975.
144. Biddle SJH, Atkin AJ, Cavill N, Foster C. Correlates of physical activity in youth: A review of quantitative systematic reviews. *Int Rev Sport Exerc Psychol*. 2011;4(1):25-49. doi:10.1080/1750984X.2010.548528
145. Yao CA, Rhodes RE. *Parental Correlates in Child and Adolescent Physical Activity: A Meta-Analysis*. Vol 12.; 2015. doi:10.1186/s12966-015-0163-y
146. Van Der Horst K, Paw MJCA, Twisk JWR, Van Mechelen W. A brief review on correlates of physical activity and sedentariness in youth. *Med Sci Sports Exerc*. 2007;39(8):1241-1250.

doi:10.1249/mss.0b013e318059bf35
147. Culver K a, Whetten K, Boyd DL, et al. Yoga to Reduce Trauma-Related Distress and Emotional and Behavioral Difficulties Among Children Living in Orphanages in Haiti: A Pilot Study. *J Altern Compliment Med*. 2015;21(9):539-545. doi:10.1089/acm.2015.0017
148. Story M, Neumark-Sztainer D, French S. Individual and Environ Influences on Adol Eating Behaviors. *J Am Diet Assoc*. 2002;S102(3):S40-S51. doi:10.1016/S0002-8223(02)90421-9
149. Elder JP, Lytle L, Sallis JF, et al. A description of the social-ecological framework used in the trial of activity for adolescent girls (TAAG). *Health Educ Res*. 2007;22(2):155-165. doi:10.1093/her/cyl059
150. Van de Poel E, Reza Hosseinpoor A, Speybroeck N, Van Ourti T, Vega J, to Ellen Van de Poel C. *Socioeconomic Inequality in Malnutrition in Developing Countries*. Vol 86.; 2008. doi:10.2471/BLT.07.044800
151. Fotso J-C, Kuate-Defo B. Household and community socioeconomic influences on early childhood malnutrition in Africa. *J Biosoc Sci*. 2006;38(3):289-313. doi:http://dx.doi.org/10.1017/S0021932005026143
152. Menon P, Ruel MT, Morris SS. Socio-economic differentials in child stunting are consistently larger in urban than in rural areas. *Food Nutr Bull*. 2000;21(3):282-289. doi:10.1177/156482650002100305
153. Petrou S, Kupek E. Poverty and childhood undernutrition in developing countries: A multi-national cohort study. *Soc Sci Med*. 2010;71(7):1366-1373. doi:10.1016/j.socscimed.2010.06.038
154. Monteiro C, Hawkes C, Caballero B. The underweight/overweight paradox in developing societies: Causes and policy implications. In: Dube L, Bechara A, Dagher A, et al., eds. *Obesity Prevention: The Role of Brain and Society on Individual Behavior*. London: Elsevier Inc.; 2010:463-469.
155. Fernald L, Gutierrez J, Neufeld L, et al. High prevalence of obesity among the poor in Mexico. *J Am Med Assoc*. 2004;291(21):2544-2545.
156. Mclaren L. Socioeconomic Status and Obesity. *Epidemiol Rev*. 2007;29:29-48. doi:10.1093/epirev/mxm001
157. Monteiro C, Conde W, Popkin B. Income-Specific Trends in Obesity in Brazil: 1975–2003. *Am J Public Health*. 2007;97(10):1808-1812. doi:10.2105/AJPH.2006.099630
158. Monteiro C, Moura E, Conde W, Popkin B. Socioeconomic status and obesity in adult populations of developing countries: a review Public Health Reviews. *Bull World Health Organ*. 2004;82(12).
159. Fraser B. Latin America's urbanisation is boosting obesity. *Lancet*. 2005;365(9476):1995-1996.
160. Mulder C, Kain J, Uauy R, Seidell J. Maternal attitudes and child-feeding practices: relationship with the BMI of Chilean children. *Nutr J*. 2009;8(37). doi:10.1186/1475-2891-8-37
161. Ruel M. Urbanization in Latin America: Constraints and opportunities for child feeding and care. *Food Nutr Bull*. 2000;21(1):12-24.
162. Cooke L, Wardle J, Gibson E, Sapochnik M, Sheiham A, Lawson M. Demographic, familial and trait predictors of fruit and vegetable consumption by pre-school children. *Public Health Nutr*. 2004;7(2):295-302. doi:10.1079/PHN2003527
163. Bante H, Elliott M, Harrod A, Haire-Joshu D. The use of inappropriate feeding practices by rural parents and their effect on preschoolers' fruit and vegetable preferences and intake. *J Nutr Educ Behav*. 2008;40:28-33. doi:10.1016/j.jneb.2007.02.007
164. Grimm G, Harnack L, Story M. Factors associated with soft drink consumption in school-aged children. *J Am Diet Assoc*. 2004;104(8):1244-1249. doi:10.1016/j.jada.2004.05.206
165. Fisher J, Mitchell D, Smiciklas-Wright H, Mannino M, Birch L. Meeting calcium recommendations during middle childhood reflects mother-daughter beverage choices and predicts bone mineral status 1–3. *Am J Clin Nutr*. 2004;79(4):698-706.
166. Crepinsek M, Singh A, Bernstein L, McLaughlin J. Dietary effects of universal-free school breakfast: Findings from the evaluation of the School Breakfast Program Pilot Project. *J Am Diet Assoc*. 2006;106(11):1796-1803. doi:10.1016/j.jada.2006.08.013
167. Rose G. Sick individuals and sick populations. *Int J Epidemiol*. 2001;30(3):427-432. doi:10.1093/ije/30.3.427
168. Lytle LA. Examining the Etiology of Childhood Obesity: The IDEA Study. *Am J Community Psychol*. 2009;44(3-4). doi:10.1007/s10464-009-9269-1
169. Hales C, Barker D. Type 2 (non-insulin-dependent) diabetes mellitus: the thrifty phenotype hypothesis. *Diabetologia*. 1992;35(7):595-601. doi:10.1007/BF00400248
170. Barker D. The fetal and infant origins of adult disease. *BMJ Br Med J*. 1990;301(156):1111. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1664286/.

171. Barker DJP. The malnourished baby and infant. *Br Med Bull*. 2001;60(1):69-88. doi:10.1093/bmb/60.1.69
172. Sawaya A, Martins P, Grillo L, Florencio T. Long-term effects of early malnutrition on body weight regulation. *Nutr Rev*. 2004;62(7):S127-S133. doi:10.1301/nr.2004.jul.S127
173. Barker D, Fall C. Fetal and infant origins of cardiovascular disease. *Arch Dis Child*. 1993;68:797-799.
174. Eriksson JG. Epidemiology, genes and the environment: Lessons learned from the Helsinki Birth Cohort Study. *J Intern Med*. 2007;261(5):418-425. doi:10.1111/j.1365-2796.2007.01798.x
175. Sanders R. Adolescent psychosocial, social, and cognitive development. *Pediatr Rev*. 2013;34(8):354-359. http://pedsinreview.aappublications.org/content/pedsinreview/34/8/354.full.pdf. Accessed March 27, 2017.
176. Slentz CA, Houmard JA, Kraus WE. Modest Exercise Prevents the Progressive Disease Associated with Physical Inactivity. *Exerc Sport Sci Rev*. 2007;35(1):18-23. doi:10.1249/01.jes.0000240019.07502.01
177. Booth FW, Gordon SE, Carlson CJ, Hamilton MT. *Waging War on Modern Chronic Diseases: Primary Prevention through Exercise Biology*.; 2000. http://www.jap.org. Accessed September 14, 2018.
178. Booth FW, Roberts CK, Laye MJ. Lack of exercise is a major cause of chronic diseases. *Compr Physiol*. 2012;2(2):1143-1211. doi:10.1002/cphy.c110025
179. Iannotti LL, Henretty NM, Delnatus JR, et al. Ready-to-Use Supplementary Food Increases Fat Mass and BMI in Haitian School-Aged Children. *J Nutr*. 2015;145(4):813-822. doi:10.3945/jn.114.203182
180. Khambalia AZ, Dickinson S, Hardy LL, Gill T, Baur LA. A synthesis of existing systematic reviews and meta-analyses of school-based behavioural interventions for controlling and preventing obesity. *Obes Rev*. 2012;13(3):214-233. doi:10.1111/j.1467-789X.2011.00947.x
181. Iannotti L, Dulience SJL, Joseph S, et al. Fortified snack reduced anemia in rural school-aged children of Haiti: A cluster-randomized, controlled trial. *PLoS One*. 2016;11(12):1-14. doi:10.1371/journal.pone.0168121
182. WHO. Interventions on diet and physical activity: what works: summary report. doi:10.1017/CBO9781107415324.004
183. Waters E, de S-SA, Burford BJ, et al. Interventions for preventing obesity in children. *Cochrane Database Syst Rev*. 2011;(12). doi:10.1002/14651858.CD001871.pub3
184. Brennan LK, Brownson RC, Orleans CT. Childhood Obesity Policy Research and Practice Evidence for Policy and Environmental Strategies. *Am J Prev Med*. 2014;46(1):e1-16. doi:10.1016/j.amepre.2013.08.022
185. Naidoo R, Science MS, Phil YCD, et al. Impact of a primary school-based nutrition and physical activity intervention on learners in KwaZulu-Natal , South Africa : A pilot study. 2009;21(1):7-12.
186. Blome J. Measuring Value: Using Program Evaluation to Understand What's Working -- Or Isn't. In: *MORE Program Directors Meeting*. Colorado Springs, CO; 2009. https://slideplayer.com/slide/3062357/.
187. Lutter C, Iannotti L, Creed-Kanashiro H, et al. Key principles to improve programmes and interventions in complementary feeding. *Matern Child Nutr*. 2013;9(Suppl 2):101-115. doi:10.1111/mcn.12087
188. Svedberg P. *Poverty and Undernutrition: Theory, Measurement, and Policy*. New York: Oxford; 2000.
189. Bhattacharyya AK. Composite index of anthropometric failure (CIAF) classification: Is it more useful? [1]. *Bull World Health Organ*. 2006;84(4):335. doi:/S0042-96862006000400023
190. FAOSTAT. Food and Agriculture Data. http://www.fao.org/faostat/en/#home. Published 2015. Accessed October 16, 2018.
191. IOM. *Dietary Reference Intakes: A Risk Assessment Model for Establishing Upper Intake Levels for Nutrients*. (National Academy Press, ed.). Washington, DC; 1998.
192. IOM. *Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride*. Washington, DC: National Academies Press; 1997.
193. IOM. *Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin, and Choline*. Washington, DC: National Academies Press; 1998.
194. IOM. *Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium and Carotenoids*. Washington, DC: National Academies Press; 2000.
195. IOM. *Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybde-Num, Nickel, Silicon, Vanadium, and Zinc*. Washington, DC: National Academies Press; 2000.
196. IOM. *Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate*. Washington, DC: National Academies Press; 2004.
197. IOM. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients)*. Washington, DC: National Academies Press; 2005.
198. ADA. Practice Paper of the American Dietetic Association: Using the Dietary Reference Intakes. *YJADA*.

2011;111:762-770. doi:10.1016/j.jada.2011.03.022
199. Kennedy G, Ballard T, Dop M. *Guidelines for Measuring Household and Individual Dietary Diversity*. Washington, DC; 2010. http://www.fao.org/3/a-i1983e.pdf. Accessed June 10, 2016.
200. Hoddinott J, Yohannes Y. Dietary diversity as a food security indicator. *IFPRI Food Consum Nutr Div Pap*. 2002;136.
201. Hatloy A, Hallund J, Diarra M, Oshaug A. Food variety, socioeconomic status and nutritional status in urban and rural areas in Koutiala (Mali). *Public Health Nutr*. 2000;3(1):57-65.
202. Shah N, Braverman E. Measuring adiposity in patients: The utility of Body Mass Index (BMI), percent body fat, and leptin. *PLoS One*. 2012;7(4). doi:10.1371/journal.pone.0033308
203. Rothman K. BMI-related errors in the measurement of obesity. *Int J Obes*. 2008;32:56-59. doi:10.1038/ijo.2008.87
204. Siri W. Body composition from fluid spaces and density: Analysis of methods. In: Brozek J, Henschel A, eds. *Techniques for Measuring Body Composition*. Washington, DC: National Academy of Sciences National Research Council; 1961:223–244.
205. Lifson N, Gordon G, R M. Measurement of total carbon dioxide production by means of D2O18. *J Appl Physiol*. 1955;7:704-710.
206. Buchowski MS. Doubly Labeled Water Is a Validated and Verified Reference Standard in Nutrition Research. *J Nutr*. 2014;144(5):573-574. doi:10.3945/jn.114.191361
207. Sallis JF. Self-Report Measures of Children's Physical Activity. *J Sch Health*. 2018;61(5):215-219. doi:10.1111/j.1746-1561.1991.tb06017.x
208. Jacobs DR, Ainsworth BE, Hartman TJ, Leon AS. A simultaneous evaluation of 10 commonly used physical activity questionnaires. *Med Sci Sport Exerc*. 1993;25(1):81-91.
209. Westerterp KR. Assessment of physical activity: a critical appraisal. *Eur J Appl Physiol*. 2009;105(6):823-828. doi:10.1007/s00421-009-1000-2
210. Besson H, Brage S, Jakes RW, Ekelund U, Wareham NJ. Estimating physical activity energy expenditure, sedentary time, and physical activity intensity by self-report in adults. *Am J Clin Nutr*. 2010;91(1):106-114. doi:10.3945/ajcn.2009.28432
211. Ishikawa-Takata K, Tabata I, Sasaki S, et al. Physical activity level in healthy free-living Japanese estimated by doubly labelled water method and International Physical Activity Questionnaire. *Eur J Clin Nutr*. 2008;62(7):885-891. doi:10.1038/sj.ejcn.1602805
212. Baranowski T, Dworkin RJ, Cieslik CJ, et al. Reliability and Validity of Self Report of Aerobic Activity: Family Health Project. *Res Q Exerc Sport*. 1984;55(4):309-317. doi:10.1080/02701367.1984.10608408
213. Klesges RC, Eck LH, Mellon MW, Fulliton W, Somes GW, Hanson CL. The accuracy of self-reports of physical activity. *Med Sci Sports Exerc*. 1990;22(5):690-697. doi:10.1249/00005768-199010000-00022
214. Uitenbroek DG. Seasonal variation in leisure time activity. 1993:755-760.
215. Durante R, Ainsworth BE. The recall of physical activity: Using a cognitive model of the question-answering process. *Med Sci Sports Exerc*. 1996;28(10):1282-1291. doi:10.1097/00005768-199610000-00012
216. Vanhees L, Lefevre J, Philippaerts R, Martens M. How to assess physical activity ? How to assess physical fitness ? Copyright © European Society of. *Eur J Cardiovasc Prev Rehabil*. 2015;12(2).
217. Van Der Ploeg HP, Merom D, Chau JY, Bittman M, Trost SG, Bauman AE. Advances in population surveillance for physical activity and sedentary behavior: Reliability and validity of time use surveys. *Am J Epidemiol*. 2010;172(10):1199-1206. doi:10.1093/aje/kwq265
218. Tudor-locke C, Ploeg HP Van Der, Bowles HR, et al. Walking behaviours from the 1965–2003 American Heritage Time Use Study (AHTUS). *Int J Behav Nutr Phys Act*. 2007;4(45). doi:10.1186/1479-Received
219. Ling FCM, Masters RSW, McManus AM. Rehearsal and pedometer reactivity in children. *J Clin Psychol*. 2011;67(3):261-266. doi:10.1002/jclp.20745
220. Hardy LL, Hills AP, Timperio A, et al. A hitchhiker's guide to assessing sedentary behaviour among young people: Deciding what method to use. *J Sci Med Sport*. 2013;16(1):28-35. doi:10.1016/j.jsams.2012.05.010
221. Sleap M, Warburton P. Physical activity levels of 5-11-year-old children in England: cumulative evidence from three direct observation studies. *Int J Sports Med*. 1996;17(4):248-253. doi:10.1055/s-2007-972841
222. McKenzie TL. Observational measures of children's physical activity. *J Sch Health*. 1991;61(5):224-227.
223. Rachele JN, Mcphail SM, Washington TL, Cuddihy TF. Practical physical activity measurement in youth: A review of contemporary approaches. *World J Pediatr*. 2012;8(3):207-216. doi:10.1007/s12519-012-0359-z
224. Chen KY, Bassett DR. The technology of accelerometry-based activity monitors: Current and future. *Med*

Sci Sports Exerc. 2005;37(11 SUPPL.). doi:10.1249/01.mss.0000185571.49104.82
225. Freedson P, Pober D, Janz KF. Calibration of Accelerometer Output for Children. *Med Sci Sports Exerc*. 2005;37(11 SUPPL.):523-530. doi:10.1249/01.mss.0000185658.28284.ba
226. Eston RG, Rowlands A V., Ingledew DK. Validity of heart rate, pedometry, and accelerometry for predicting the energy cost of children's activities. *J Appl Physiol*. 1998;84:362-371. doi:10.1158/1940-6207.capr-14-0132
227. Dishman RK. The measurement conundrum in exercise. *Med Sci Sport Exerc*. 1994;26(11):1382-1390.
228. Loprinzi P, Lee H, Cardinal B, Crespo C, Andersen R, Smit E. The Relationship of Actigraph Accelerometer Cut-Points for Estimating ... *Rsearch Q Exerc Sport*. 2012;83(3):422-430. doi:10.1080/02701367.2012.10599877
229. McClain JJ, Tudor-Locke C. Objective monitoring of physical activity in children: considerations for instrument selection. *J Sci Med Sport*. 2009;12(5):526-533. doi:10.1016/j.jsams.2008.09.012
230. Tudor-Locke C, Williams JE, Reis JP, Pluto D. Utility of Pedometers for Assessing Physical Activity. *Sport Med*. 2002;32(12):795-808. doi:10.2165/00007256-200232120-00004
231. Freedson PS, Miller K. Objective monitoring of physical activity using motion sensors and heart rate. *Res Q Exerc Sport*. 2000;71:21-29. doi:10.1080/02701367.2000.11082782
232. Trost SG. Objective measurement of physical activity in youth: current issues, future directions. *Exerc Sport Sci Rev*. 2001;29(1):32-36.
233. McNamara E, Hudson Z, Taylor SJC. Measuring activity levels of young people: the validity of pedometers. *Br Med Bull*. 2010;95:121-137. doi:10.1093/bmb/ldq016
234. Schmidt MDB. Practical Considerations When Using Pedometers to Assess Physical ... 2007.
235. Welk GJ, Corbin CB. The Validity of the Tritrac-R3D Activity Monitor for the Assessment of Physical Activity in Children. *Res Q Exerc Sport*. 1995;66(3):202-209. doi:10.1080/02701367.1995.10608834
236. Sirard JR, Pate RR. Physical activity assessment in children and adolescents. *Sports Med*. 2001;31(6):439-454. doi:10.2165/00007256-200131060-00004
237. Pahkala K, Heinonen OJ, Lagstrom H, Hakala P, Sillanmaki L, Simell O. Leisure-time physical activity of 13-year-old adolescents. *Scand J Med Sci Sports*. 2007;17(4):324-330. doi:10.1111/j.1600-0838.2006.00581.x
238. Macfarlane DJ, Lee CCY, Ho EYK, Chan KL, Chan D. Convergent validity of six methods to assess physical activity in daily life. *J Appl Physiol*. 2006;101(5):1328-1334. doi:10.1152/japplphysiol.00336.2006
239. Terbizan DJ, Dolezal BA, Albano C. Validity of Seven Commercially Available Heart Rate Monitors. *Meas Phys Educ Exerc Sci*. 2002;6(4):243-247. doi:10.1207/S15327841MPEE0604_3
240. UCPNANu. Plan Stratégique National de Nutrition. *Rapp du Ministère la Santé Publique la Popul*. 2013.
241. Bureau De La Première Dame de la République d'Haïti. *Note Conceptuelle Du Programme National de Lutte Contre La Faim et La Malnutrition*.; 2012.
242. SUN. About SUN. Scaling Up Nutrition Website. http://scalingupnutrition.org/about. Published 2014. Accessed February 2, 2016.
243. SUN. Bringing People Together: Haiti. Scaling Up Nutrition Website. http://scalingupnutrition.org/sun-countries/haiti/bringing-people-together. Published 2014. Accessed February 2, 2016.
244. FTF. Haiti Country Profile. Feed the Future Website. https://www.feedthefuture.gov/country/haiti. Published 2016. Accessed June 2, 2016.
245. FTF. *Haiti: FY 2011-2015 Multi-Year Stratgey*.; 2011.
246. Partners of the Americas, USAID. Haiti Nutrition Security Program. Partners of the Americas Website. http://www.haitinutrition.org/. Published 2015. Accessed June 2, 2016.
247. Rahmaan CA. *Haiti Nutrition Security Program (NSP)*.; 2015.
248. USAID. Haiti. FANTA III Website. http://www.fantaproject.org/countries/haiti. Published 2015. Accessed June 2, 2016.
249. USAID. SPRING/Haiti. USAID Website. https://www.spring-nutrition.org/countries/haiti#publications. Published 2014. Accessed February 2, 2016.
250. USAID. Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING). USAID Global Health Fact Sheet: Haiti. doi:https://www.usaid.gov/kyrgyz-republic/fact-sheets/strengthening-partnerships-results-and-innovations-nutrition-globally
251. USAID. *Haiti: Final Country Report- Fiscal Years 2012-2015*. Arlington, VA; 2015. www.spring-nutrition.org. Accessed July 8, 2016.
252. USAID. *Baseline Study of the Title II Development Food Assistance Program in Haiti*. Arlington, VA;

2015. https://www.flickr.com/photos/46658241@N06/5093680654/. Accessed July 8, 2016.
253. USAID. Food Assistance: Haiti. USAID Website. https://www.usaid.gov/haiti/food-assistance. Published 2016. Accessed July 8, 2016.
254. WFP. Countries: Haiti. World Food Programme Website. http://www.wfp.org/countries/haiti/overview. Published 2016. Accessed February 2, 2016.
255. UNICEF Devision of Policy and Strategy. *Committing to Child Survival: A Promise Renewed*. New York; 2012.
256. Horton S, Steckel R. *Malnutrition: Global Economic Losses Attributable to Malnutrition 1900–2000 and Projections to 2050*.; 2013. http://www.copenhagenconsensus.com/sites/default/files/malnutrition.pdf.
257. IFPRI. *2015 Global Nutrition Report: Actions and Accountability to Advance Nutrition & Sustainable Development*. Washngton, DC; 2015.
258. Alaofè H, Zee J, Dossa R, O'Brien HT. Education and improved iron intakes for treatment of mild iron-deficiency anemia in adolescent girls in southern Benin. *Food Nutr Bull*. 2009;30(1):24-36.
259. Desai KT, Nayak SN, Patel PB, Modi BP, Gharat V, Bansal R. Follow-up Assessment of Under-nourished Children Under Integrated Child Development Services Scheme in Tapi District, India. *Int J Prev Med*. 2014;5(6):758-766. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4085929/.
260. Dossa R a, Ategbo E a, de Koning FL, van Raaij JM, Hautvast JG. Impact of iron supplementation and deworming on growth performance in preschool Beninese children. *Eur J Clin Nutr*. 2001;55(4):223-228. doi:10.1038/sj.ejcn.1601126
261. European Parliament. *The Social and Economic Consequences of Malnutrition in ACP Countries*.; 2014.
262. Glewwe P, Kassouf AL. The Impact of the Bolsa Escola/Familia conditional crash transfer program on enrollment, drop out rates, and grade promotion in Brazil. *J Dev Econ*. 2008;97(2):505-517.
263. Gragnolati M, Bredenkamp C, Gupta M Das, Lee Y, Shekar M. ICDS and persistent undernutrition: Strategies to enhance the impact. *Econ Polit Wkly*. 2012;41(12):1193-1201.
264. Hall A. Brazil's Bolsa Família: A double-edged sword? *Dev Change*. 2008;39(5):799-822. doi:10.1111/j.1467-7660.2008.00506.x
265. Hirve S, Martini E, Juvekar SK, et al. Delivering sprinkles plus through the integrated child development services (ICDS) to reduce anemia in pre-school children in India. *Indian J Pediatr*. 2013;80(12):990-995. doi:10.1007/s12098-013-1063-2
266. Hughes EM. Conditional Cash Transfers in a Neoliberal Era: The evolution of Mexico's Progresa-Oportunidades. *Dr Diss Saint Mary's Univ*. 2015. doi:10.1017/CBO9781107415324.004
267. Jennings-Aburto N, Nava F, Bonvecchio A, et al. Physical activity during the school day in public primary schools in Mexico City. *Salud Publica Mex*. 2009;51(2).
268. Kapil U. Integrated Child Development Services (ICDS) scheme: a program for holistic development of children in India. *Indian J Pediatr*. 2002;69(7):597-601. doi:10.1007/BF02722688
269. Attanasio O, Meghir C, Santiago A. Education choices in Mexico: using a structural model and a randomised experiment to evaluate PROGRESA. *IFS Work Pap*. 2010. http://eprints.ucl.ac.uk/14748/.
270. Levesque S, Delisle H, Agueh V. Contribution to the development of a food guide in Benin: linear programming for the optimization of local diets. *Public Health Nutr*. 2015;18(4):622-631. doi:10.1017/S1368980014000706
271. Ministério da Saúde. PNAN: Política Nacional de Alimentação e Nutrição. 2012.
272. Morris SS, Olinto P, Flores R, Nilson E a F, Figueiró AC. Conditional cash transfers are associated with a small reduction in the rate of weight gain of preschool children in northeast Brazil. *J Nutr*. 2004;134(9):2336-2341. doi:134/9/2336 [pii]
273. Neufeld LM, Rivera J, Valle AM, Grados R, Uriega S, Lo VH. Evaluation for Program Decision Making: A Case Study of the Oportunidades Program. *J Nutr*. 2011;141:2076-2083. doi:10.3945/jn.110.134957.Published
274. Olaiz G, Rivera J, Shamah T, et al. *Encuesta Nacional de Salud y Nutrición 2006 Actividad Física En Adolescentes*. Instituto Nacional de Salud Pública; 2006.
275. PHFI. *Annual Report 2012-13*.; 2013.
276. PHFI. Healthy India. http://www.healthy-india.org/about_us.php. Published 2013. Accessed June 1, 2016.
277. PHFI. About PHFI. https://phfi.org/about-us/about-phfi. Published 2015. Accessed June 1, 2016.
278. Pimenta TAM, Rocha R, Marcondes NAV. Políticas Públicas de Intervenção na Obesidade Infantil no Brasil : uma Breve Análise da Política Nacional de Alimentação e Nutrição e Política Nacional de Promoção da Saúde. *UNOPAR - Rev científica Ciências Biológicas e Saúde*. 2015;17(2):139-146. doi:10.17921/2447-

8938.2015
279. Rasella D, Aquino R, Santos C a T, Paes-sousa R, Barreto ML. Effect of a conditional cash transfer programme on childhood mortality: a nationwide analysis of Brazilian municipalities. *Lancet*. 2013;6736(13):1-10.
280. Barquera S, Rivera-Dommarco J, Gasca-García A. Políticas y programas de alimentación y nutrición en México. *Salud Publica Mex*. 2001;43(5):464-477. doi:10.1590/S0036-36342001000500011
281. Rivera Castiñeira B, Currais Nunes L, Rungo P. Impacto de los programas de transferencia condicionada de renta sobre el estado de salud: el programa bolsa familia de Brasil. *Rev Esp Salud Pública*. 2009;83(1):85-97.
282. Rivera JA, Rodriguez G, Shamah T, et al. Implementation, monitoring, and evaluation of the nutrition component of the Mexican social programme (PROGRESA). *Food Nutr Bull*. 2000;21(1):35-42.
283. Shei A, Costa F, Reis MG, Ko AI. The impact of Brazil's Bolsa Família conditional cash transfer program on children's health care utilization and health outcomes. *BMC Int Health Hum Rights*. 2014;14(1):10. doi:10.1186/1472-698X-14-10
284. Skoufias E. *PROGRESA and Its Impacts on the Welfare of Rural Households in Mexico*.; 2005. http://www.scopus.com/inward/record.url?eid=2-s2.0-29244447430&partnerID=tZOtx3y1.
285. Soares F, Soares S, Medeiros M, Osorio R. *Cash Transfers Programmes in Brazil: Impacts on Inequality and Poverty*.; 2006. doi:ISSN: 1812-108X
286. Soares FV, Ribas RP, Osório RG. Evaluating the impact of Brazil's Bolsa Familia cash transfer programs in comparative perspective. *Lat Am Res Rev*. 2010;45(2):173-190.
287. Tandon BN. Nutritional interventions through primary health care: impact of the ICDS projects in India. *Bull World Health Organ*. 1989;67:77-80.
288. UKAID. *Strengthening Public Health Nutrition Education in India*.; 2014.
289. WHO. Brazil's march towards universal coverage. Bulletin of the World Health Organization. http://www.who.int/bulletin/volumes/88/9/10-020910/en/. Published 2011. Accessed July 7, 2016.
290. World Bank. India: ICDS Systems Strengthening & Nutrition Improvement Program (ISSNIP). Project Publication. http://www.worldbank.org/projects/P121731/icds-systems-strengthening-nutrition-improvement-program-issnip?lang=en. Published 2012.
291. Barros da Guarda FR, da Silva RN, de Fátima Freitas MI, dos Santos Neto PM, Correia de Araújo Júnior JL do A. Intervención do profissional de educação física: formação, perfil e competências para atuar no Programa Academia da Saúde. *Rev Pan-Amaz Saude*. 2014;5(4):63-74. doi:10.5123/S2176-62232014000400008
292. Zarco A, Mora G, Pelcastre B, Flores M, Bronfman M. Aceptabilidad de los suplementos alimenticios del programa Oportunidades. *Salud Publica Mex*. 2006;48(4):325-331. doi:10.1590/S0036-36342006000400007
293. Barros Da Guarda FR, Niels Da Silva R, do Nascimento Feitosa WM, dos Santos Neto PM, Correia De Araújo Júnior JLA. Caracterização das equipes do Programa Academia da Saúde e do seu processo de trabalho. *Rev Bras Atividade Física Saúde*. 2015;20(6):638-640. doi:10.12820/rbafs.v.20n6p638
294. Behrman JR, Hoddinott J. An evaluation of the impact of PROGRESA on child height. *Int Food Policy Res Institute, Washington, DC*. 2001;(104).
295. Chudasama RK, Patel U V, Verma PB, et al. Evaluation of Anganwadi centres performance under Integrated Child Development Services (ICDS) program in Gujarat State , India during year 2012-13. *J Mahatma Gandhi Inst Med Sci*. 2015;20(1):60-65.
296. Córdova-Villalobos JA. Sobrepeso y obesidad, problemas de salud pública en México. *Cir Cir*. 2009;77(6):421-422.
297. Delisle HF, Receveur O, Agueh V, Nishida C. Pilot project of the Nutrition-Friendly School Initiative (NFSI) in Ouagadougou, Burkina Faso and Cotonou, Benin, in West Africa. *Glob Heal Promot*. 2013;20(1):39-49. doi:10.1177/1757975913476907
298. Slentz CA, Houmard JA, Kraus WE. Exercise, abdominal obesity, skeletal muscle, and metabolic risk: evidence for a dose response. *Obes (Silver Spring)*. 2009;17 Suppl 3(0 3):S27-S33. doi:10.1038/oby.2009.385
299. GOPA. Global Physical Activity Facts. Global Observatory for Physical Activity. http://www.globalphysicalactivityobservatory.com/facts/. Published 2016. Accessed November 14, 2018.
300. GOPA. *Haiti Country Card*. Global Observatory for Physical Activity; 2016. http://www.globalphysicalactivityobservatory.com/card/?country=HT.

301. FAO, IFAD, UNICEF, WFP, WHO. *Panorama of Food and Nutrition Security in Latin America and the Caribbean. 2017*.; 2017.
302. Mazzeo J. Humanitarian Assistance or Corporate Interest ? Monsanto and USAID in Haiti Humanitarian Assistance or Corporate Interest ? *Anthropol News*. January 2012.
303. IndexMundi. Haiti Urbanization - Demographics. IndexMundi Country Demographics. https://www.indexmundi.com/haiti/urbanization.html. Published 2018. Accessed November 14, 2018.
304. IndexMundi. Haiti - Child obesity. https://www.indexmundi.com/facts/haiti/child-obesity. Accessed November 7, 2018.
305. IndexMundi. Haiti - Adult Obesity. https://www.indexmundi.com/g/g.aspx?v=2228&c=ha&l=en. Accessed November 12, 2018.
306. Craig CL, Marshall AL, Sjöström M, et al. International physical activity questionnaire: 12-Country reliability and validity. *Med Sci Sports Exerc*. 2003;35(8):1381-1395. doi:10.1249/01.MSS.0000078924.61453.FB
307. WHO. *Global Recommendationson Physical Activity for Health: 5-17 Years Old*.; 2011. http://www.who.int/dietphysicalactivity/pa/en/index.html.
308. Shiroma E, Kamada M, Smith C, Harris T, Lee I. Visual Inspection for Determining Days when Accelerometer is Worn: Is this Valid? *Med Sci Sport Exerc*. 2015;47(12):2558-2562. doi:10.1249/MSS.0000000000000725
309. Dyrstad SM, Hansen BH, Holme IM, Anderssen SA. Comparison of self-reported versus accelerometer-measured physical activity. *Med Sci Sports Exerc*. 2014;46(1):99-106. doi:10.1249/MSS.0b013e3182a0595f
310. Iannotti LL, Dulience SJL, Green J, et al. Linear growth increased in young children in an urban slum of Haiti: A randomized controlled trial of a lipid-based nutrient supplement. *Am J Clin Nutr*. 2014;99(1):198-208. doi:10.3945/ajcn.113.063883
311. Sanchez A, Norman GJ, Sallis JF, Calfas KJ, Cella J, Patrick K. Patterns and Correlates of Physical Activity and Nutrition Behaviors in Adolescents. *Am J Prev Med*. 2007;32(2):124-130. doi:10.1016/j.amepre.2006.10.012
312. Graham DJ, Bauer KW, Friend S, Barr-Anderson DJ, Nuemark-Sztainer D. Personal, Behavioral, and Socioenvironmental Correlates of Physical Activity among Adolescent Girls: Cross-Sectional and Longitudinal Associations. *J Phys Act Heal*. 2014;11(1):51-61. doi:10.1123/jpah.2011-0239
313. Caspersen CJ, Pereira MA, Curran KM. Changes in physical activity patterns in the United States, by sex and cross-sectional age. *Med Sci Sport Exerc*. 2000;32(9):1601-1609.
314. Hallal P, Andersen L, Bull F, Guthold R, Haskell W, Ekelund U. Global physical activity levels: surveillance progress, pitfalls, and prospects. The. *Lancet*. 2012;380:247-257.
315. Nader PR, Bradley RH, Houts RM, Mcritchie SL, Brien MO. Moderate-to-Vigorous Physical Activity From Ages 9 to 15 Years. *J Am Med Assoc*. 2008;300(3):295-305.
316. Sallis JF. Epidemiology of physical activity and fitness in children and adolescents, Critical Reviews in Food Science and Nutrition. *Crit Rev Food Sci Nutr*. 1993;33(4-5):403-408.
317. Gustafson SL, Rhodes RE. Parental correlates of physical activity in children and early adolescents. *Sport Med*. 2006;36(1):79-97. doi:10.2165/00007256-200636010-00006
318. Larouche R. Physical inactivity in developing countries. *Cmaj*. 2014;186(14):1092. doi:10.1503/cmaj.114-0071
319. Stalsberg R, Pedersen AV. Are differences in physical activity across socioeconomic groups associated with choice of physical activity variables to report? *Int J Environ Res Public Health*. 2018;15(5). doi:10.3390/ijerph15050922
320. Lozano-Gracia N, García Lozano M. Haitian Cities: Actions for Today with and Eye on Tomorrow. 2017.
321. Popkin BM. Urbanization, lifestyle changes and the nutrition transition. *World Dev*. 1999;27(11):1905-1916. doi:10.1016/S0305-750X(99)00094-7
322. Prentice A, Schoenmakers I, Ann Laskey M, de Bono S, Ginty F, Goldberg GR. Nutrition in growth and development. *Proc Nutr Soc*. 2006;65(4):348-360. doi:10.1079/PNS2006519
323. Rogol AD, Clark PA, Roemmich JN. Growth and pubertal development in children and adolescents: Effects of diet and physical activity. *Am J Clin Nutr*. 2000;72(2 SUPPL.). doi:10.3390/molecules21010096
324. Iannotti L, Jean Louis Dulience S, Wolff P, Cox K, Lesorogol C, Kohl P. Nutrition factors predict earlier acquisition of motor and language milestones among young children in Haiti. *Acta Paediatr Int J Paediatr*. 2016;105(9):e406-e411. doi:10.1111/apa.13483
325. Groos AD. Delayed motor development in relation to nutritional status among children under two years of

age in two districts of Simbu Province. *P N G Med J*. 1991;34(4):238-245. http://www.ncbi.nlm.nih.gov/pubmed/1724715. Accessed October 29, 2018.
326. Sachdev H, Gera T, Nestel P. Effect of iron supplementation on mental and motor development in children: systematic review of randomised controlled trials. *Public Health Nutr*. 2005;8(02):117-132. doi:10.1079/PHN2004677
327. Black MM, Baqui AH, Zaman K, et al. Iron and zinc supplementation promote motor development and exploratory behavior among Bangladeshi infants. *Am J Clin Nutr*. 2004;80(4):903-910. doi:80/4/903 [pii]
328. Iannotti LL, Tielsch JM, Black MM, Black RE. Iron supplementation in early childhood: health benefits and risks. *Am J Clin Nutr*. 2006;84(6):1261-1276. doi:84/6/1261 [pii]
329. POLLITT E, GRANOFF DAN. Mental and Motor Development of Peruvian Children Treated for Severe Malnutrition. *Rev Interam Psicol*. 1967;1(2):93-102. doi:10.30849/RIP/IJP.V1I2.435
330. Barnett LM, van Beurden E, Morgan PJ, Brooks LO, Beard JR. Childhood Motor Skill Proficiency as a Predictor of Adolescent Physical Activity. *J Adolesc Heal*. 2009;44(3):252-259. doi:10.1016/j.jadohealth.2008.07.004
331. Lander N, Morgan PJ, Salmon J, Barnett LM. Improving Early Adolescent Girls' Motor Skill: A Cluster Randomized Controlled Trial. *Med Sci Sports Exerc*. 2017;49(12):2498-2505. doi:10.1249/MSS.0000000000001382
332. Stodden DF, Langendorfer SJ, Goodway JD, et al. A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. *Quest*. 2008;60(2):290-306. doi:10.1080/00336297.2008.10483582
333. Fine LJ, Philogene GS, Gramling R, Coups EJ, Sinha S. Prevalence of multiple chronic disease risk factors: 2001 National Health Interview Survey. *Am J Prev Med*. 2004;27(SUPPL.):18-24. doi:10.1016/j.amepre.2004.04.017
334. Berrigan D, Dodd K, Troiano RP, Krebs-Smith SM, Ballard Barbash R. Patterns of health behavior in U.S. adults. *Prev Med (Baltim)*. 2003;36(5):615-623. doi:10.1016/S0091-7435(02)00067-1
335. Pronk NP, Anderson LH, Crain AL, et al. Meeting recommendations for multiple healthy lifestyle factors: Prevalence, clustering, and predictors among adolescent, adult, and senior health plan members. *Am J Prev Med*. 2004;27(SUPPL.):25-33. doi:10.1016/j.amepre.2004.04.022
336. Demographic and Health Surveys Program. Questionnaires and Modules. https://dhsprogram.com/What-We-Do/Questionnaires.cfm. Published 2016. Accessed January 16, 2016.
337. USAID, FANTA, UC Davis, IFPRI, UNICEF, WHO. *Indicators for Assessing Infant and Young Child Feeding Practices; Part 3 Country Profiles*.; 2010. https://www.unicef.org/nutrition/files/IYCF_Indicators_part_III_country_profiles.pdf. Accessed September 24, 2018.
338. TY H, M K. Dietary Diversity Score: A Measure of Nutritional Adequacy or an Indicator of Healthy Diet? *J Nutr Heal Sci*. 2016;3(3):15-17. doi:10.15744/2393-9060.3.303
339. Newby PK, Tucker KL. Empirically derived eating patterns using factor or cluster analysis: A review. *Nutr Rev*. 2004;62(5):177-203. doi:10.1301/nr.2004.may.177-203
340. Wrotniak BH, Epstein LH, Dorn JM, Jones KE, Kondilis VA. The relationship between motor proficiency and physical activity in children. *Pediatrics*. 2006;118(6):2531.
341. Riethmuller AM, Jones RA, Okely AD. Efficacy of Interventions to Improve Motor Development in Young Children: A Systematic Review. *Pediatrics*. 2009;124(4):e782-e792. doi:10.1542/peds.2009-0333
342. De Oliveira Otto MC, Padhye NS, Bertoni AG, Jacobs DR, Mozaffarian D. Everything in moderation - Dietary diversity and quality, central obesity and risk of diabetes. *PLoS One*. 2015;10(10):1-16. doi:10.1371/journal.pone.0141341
343. Krishna J, Mishra C, Singh G. Dietary Diversity of Urban Adolescent Girls in Varanasi. *Indian J Prev Soc Med*. 2012;43(3):1-5.
344. Zhang Q, Chen X, Liu Z, Varma DS, Wan R, Zhao S. Diet diversity and nutritional status among adults in southwest China. *PLoS One*. 2017;12(2):e0172406. https://doi.org/10.1371/journal.pone.0172406.
345. O'Grady KA, Orton JD, Stewart CK, Flythe WW, Snyder NC, Desius J-P. Resilience in the Wake of Disasters: A Two-Wave Qualitative Study of Survivors of the 2010 Haiti Earthquake. *J Psychol Christ*. 2018;37(1):43-56. http://libproxy.wustl.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=reh&AN=ATLAiG0V180709000419&site=ehost-live&scope=site.
346. Gupta K. Seeking information after the 2010 Haiti earthquake: A case study in mass-fatality management.

1st IIMA Int Conf Adv Healthc Manag Serv. 2015. http://digital.library.unt.edu/ark:/67531/metadc271823/m2/1/high_res_d/dissertation.pdf.
347. Conserve DF, Eustache E, Oswald CM, et al. Maternal HIV Illness and its Impact on Children's Well-being and Development in Haiti. *J Child Fam Stud*. 2015;24(9):2779-2785. doi:10.1007/s10826-014-0081-7
348. Pierre S, Riviera V, Jean CP, et al. Live with the Disease Like You Used to Before You Knew You Were Infected: A Qualitative Study Among 10-Year Survivors Living with HIV in Haiti. *AIDS Patient Care STDS*. 2017;31(3):145-151. doi:10.1089/apc.2016.0192
349. Lesorogol C, Jean-Louis S, Green J, Iannotti L. Preventative lipid-based nutrient supplements (LNS) and young child feeding practices: Findings from qualitative research in Haiti. *Matern Child Nutr*. 2015;11:62-76. doi:10.1111/mcn.12122
350. Beckett AG, Humphries D, Jerome JG, Teng JE, Ulysse P, Ivers LC. Acceptability and use of ready-to-use supplementary food compared to corn-soy blend as a targeted ration in an HIV program in rural Haiti: A qualitative study. *AIDS Res Ther*. 2016;13(1):1-9. doi:10.1186/s12981-016-0096-9
351. Parker L, Francois K, Desinor O, Cela T, Fleischman Foreit KG. A qualitative analysis of savings and internal lending communities in Haiti???do they make a difference? *Vulnerable Child Youth Stud*. 2017;12(1):81-89. doi:10.1080/17450128.2016.1263773
352. Reginald Fils-Aime J, Grelotti DJ, Thérosme T, et al. A mobile clinic approach to the delivery of community-based mental health services in rural Haiti. *PLoS One*. 2018;13(6):1-16. doi:10.1371/journal.pone.0199313
353. Roysircar G, Colvin KF, Afolayan AG, Thompson A, Robertson TW. Haitian children's resilience and vulnerability assessed with House–Tree–Person (HTP) drawings. *Traumatology (Tallahass Fla)*. 2017;23(1):68-81. doi:10.1037/trm0000090
354. Riggs N, Tewari A, Stigler M, et al. Indian Students' Perspectives on Obesity and School-Based Obesity Prevention: A Qualitative Examination. *Health Promot Pract*. 2013;14(6):816-823. doi:10.1177/1524839913502203
355. Madrigal L, Adams I, Chacon V, Barnoya J. Perceived barriers to achieving a healthy weight: A qualitative study using focus groups at public and private schools in Guatemala City. *BMC Public Health*. 2017;17(1):1-7. doi:10.1186/s12889-016-3978-9
356. Peykari N, Eftekhari MB, Tehrani FR, et al. Promoting physical activity participation among adolescents: The barriers and the suggestions. *Int J Prev Med*. 2015;2015-Febru. doi:10.4103/2008-7802.151820
357. Ayoya MA, Heidkamp R, Ngnie-Teta I, Pierre JM, Stoltzfus RJ. Child malnutrition in Haiti: progress despite disasters. *Glob Heal Sci Pract*. 2013;1(3):389-396. doi:10.9745/GHSP-D-13-00069
358. Heidkamp RA, Ayoya MA, Teta IN, Stoltzfus RJ, Marhone JP. Breastfeeding practices and child growth outcomes in Haiti: An analysis of data from Demographic and Health Surveys. *Matern Child Nutr*. 2015;11(4):815-828. doi:10.1111/mcn.12090
359. Heidkamp RA, Ayoya MA, Teta IN, Stoltzfus RJ, Marhone JP. Complementary feeding practices and child growth outcomes in Haiti: An analysis of data from Demographic and Health Surveys. *Matern Child Nutr*. 2015;11(4):815-828. doi:10.1111/mcn.12090
360. WHO. Constitution of WHO: Principles. *About WHO*. 2016. http://www.who.int/about/mission/en/. Accessed November 13, 2018.
361. Morse M, Field A. *Qualitative Research Methods for Health Professionals*. Second Edi. (Foster D, Dickens G, eds.). Thousand Oaks, CA: Sage Publications; 1995.
362. Sundar TKB, Løndal K, Lagerløv P, Galvin K, Helseth S. Overweight adolescents' views on physical activity - Experiences of participants in an internet-based intervention: A qualitative study. *BMC Public Health*. 2018;18(1):1-11. doi:10.1186/s12889-018-5324-x
363. Taylor CC. The concept of flow in Rwandan popular medicine. *Soc Sci Med*. 1988;27(12):1343-1348. doi:10.1016/0277-9536(88)90199-2
364. Taylor CC. The harp that plays by itself. *Anthropol approaches to study ethnomedicine*. 1992:127-147.
365. Weichselbaum E, Buttriss JL. Diet, nutrition and schoolchildren: An update. *Nutr Bull*. 2014;39(1):9-73. doi:10.1111/nbu.12071
366. Monteiro C, Conde W, Popkin B. The burden of disease for undernutrition and overnutrition in countries undergoing rapid nutrition transition: A view from Brazil. *Am J Public Heal Monteiro al Peer Rev | Res Pract*. 2004;94(3):433-434.
367. Heath GW, Parra DC, Sarmiento OL, et al. Evidence-based intervention in physical activity: Lessons from around the world. *Lancet*. 2012;380(9838):272-281. doi:10.1016/S0140-6736(12)60816-2

368. Graham DJ, Sirard JR, Neumark-Sztainer D. Adolescents' attitudes toward sports, exercise, and fitness predict physical activity 5 and 10years later. *Prev Med (Baltim)*. 2011;52(2):130-132. doi:10.1016/j.ypmed.2010.11.013
369. Labatut B. Overweight affects almost half the population of all countries in Latin America and the Caribbean except for Haiti. *FAO News Article Online*. http://www.fao.org/news/story/en/item/463472/icode/. Published January 19, 2017.
370. LeBlanc A, Janssen I. Difference between self-reported and accelerometer measured moderate-to-vigorous physical activity in youth. *Pediatr Exerc Sci*. 2010;22(4):523-534.
371. Manios Y, Androutsos O, Moschonis G, et al. Criterion validity of the Physical Activity Questionnaire for Schoolchildren (PAQ-S) in assessing physical activity levels: the Healthy Growth Study. *J Sports Med Phys Fitness*. 2013;53(5):502-508. https://www.ncbi.nlm.nih.gov/pubmed/23903530.
372. Götte M, Seidel CC, Kesting SV, Rosenbaum D, Boos J. Objectively measured versus self-reported physical activity in children and adolescents with cancer. *PLoS One*. 2017;12(2):1-10. doi:10.1371/journal.pone.0172216
373. Celis-Morales CA, Perez-Bravo F, Ibañez L, Salas C, Bailey MES, Gill JMR. Objective vs. self-reported physical activity and sedentary time: Effects of measurement method on relationships with risk biomarkers. *PLoS One*. 2012;7(5). doi:10.1371/journal.pone.0036345
374. Zelener J, Schneider M. of the Modified Godin Leisure-Time Exercise Questionnaire. 2017;9(5):587-598.
375. Garriguet D, Colley RC. A comparison of self-reported leisuretime physical activity and measured moderate-to-vigorous physical activity in adolescents and adults. *Heal Reports*. 2014;25(7):3-11.
376. Arimond M, Ruel MT. Dietary Diversity Is Associated with Child Nutritional Status: Evidence from 11 Demographic and Health Surveys. *J Nutr*. 2004;134(10):2579-2585. doi:10.1093/jn/134.10.2579
377. Strong WB, Malina RM, Blimkie CJR, et al. Evidence based physical activity for school-age youth. *J Pediatr*. 2005;146(6):732-737. doi:10.1016/j.jpeds.2005.01.055
378. Ruel MT. Is Dietary Diversity an Indicator of Food Security or Dietary Quality ? a Review of Measurement Issues and Research Needs. *Food Nutr Bull*. 2003;24(2):231-232.
379. Marshall SJ, Biddle SJH, Gorely T, Cameron N, Murdey I. Relationships between media use, body fatness and physical activity in children and youth: A meta-analysis. *Int J Obes*. 2004;28(10):1238-1246. doi:10.1038/sj.ijo.0802706
380. CDC. Guidelines for School and Community Programs. *J Sch Health*. 1997;67(6):202-219.
381. HASKELL WL, LEE I-M, PATE RR, et al. Physical Activity and Public Health: Updated Recommendation for Adults From the American College of Sports Medicine and the American Heart Association. *Med Sci Sport Exerc*. 2007;39(8):1423-1434. doi:10.1249/mss.0b013e3180616b27
382. Vanhelst J, Béghin L, Duhamel A, Bergman P, Sjöström M, Gottrand F. Comparison of uniaxial and triaxial accelerometry in the assessment of physical activity among adolescents under free-living conditions: the HELENA study. *BMC Med Res Methodol*. 2012;12(26):e1-6. doi:10.1186/1471-2288-12-26
383. Bauman A, Bull F, Chey T, et al. The international prevalence study on physical activity: Results from 20 countries. *Int J Behav Nutr Phys Act*. 2009;6:1-11. doi:10.1186/1479-5868-6-21
384. MFK. *Vita Mamba School Snack*.; 2015.