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Associations between Diet Quality, Vegetable Availability and Access, and Food Security in Low-Income Children

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Associations between Diet Quality, Vegetable Availability and Access, and Food Security in Low-Income Children

by

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Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor of Philosophy

The University of Texas at Austin

August 2019

Acknowledgements

I want to express my immense gratitude to all of those who supported me throughout the process of writing this dissertation. Graduate school can be challenging and at times defeating with grant or manuscript rejections. I appreciate all the support that I have received the past four years, that have helped me build and grow from the rejections and also celebrate every little win.

I am forever grateful for Jaimie Davis for mentoring and supporting me these past four years. She is a kind and patient mentor who cares immensely about her students. She provided direction when needed while still allowing me to be autonomous and begin making important decisions. She has been my biggest cheerleader and advocate. I appreciate the many times that I went to her with my lofty goals and rather than shooting me down, she helped me build the foundation to make them a reality. My future success will be in part because of the amount of time and energy she has poured into my development as a scientist. I am incredibly appreciative of her mentorship.

I'd like to recognize my doctoral committee, Drs. Jaimie Davis, Molly Bray, Elizabeth Widen, Nalini Ranjit, and Alexandra van den Berg all of whom have questioned, counseled, and guided me on this academic journey. I appreciate all of their constructive criticism, insightful suggestions, and profound belief in my abilities.

I want to thank my fellow graduate students who have supported me throughout the course of this experience, especially those in the Davis Lab. I special thanks to Fiona Asigbee who I've been fortunate to work collaboratively with. She provided invaluable support and encouragement along the way.

I am fortunate to have been a part of the TX Sprouts project since its initial planning. It has been a truly wonderful experience to see this intervention from start to end. I am thankful of all of the staff and undergraduate volunteers who have worked tirelessly on the project over the past four years. I am especially appreciative of Katie Nikah, our amazing senior project coordinator.

I want to thank Erika Hale within the Department of Statistics and Data Sciences for all of her statistical consulting and guidance with the development of this dissertation.

To my friends scattered around the country, thank you for your thoughts, phone calls, e-mails, texts, visits, editing advice, and being there whenever I needed a friend. Lastly, I want to thank my family, especially my mom and dad for all of their unwavering support – emotionally and financially. They have always pushed me to do my very best, motivated me during the challenging times, and supported every goal that I've been inspired to pursue.

Abstract

Associations between Diet Quality, Vegetable Availability and Access, and Food Security in Low-Income Children

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The University of Texas at Austin, 2019

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Food insecurity is a pervasive problem in the United States, and has been previously associated with adverse health and wellbeing in children. The mechanism that underlies this association is assumed to be poor dietary intake, which is likely a result of lack of access to healthy, affordable foods. The purpose of this research was to examine associations between dietary quality, vegetable availability and access, and food insecurity within low-income children. Cross-sectional data from TX Sprouts, a school-based randomized controlled cooking, gardening, and nutrition intervention, were used. Public health and surveillance efforts rely on accurate measures of child food insecurity; however, research suggests that current efforts which utilize parent report of child-level food insecurity may be inaccurate or underestimate the true prevalence. The first aim was to compare child versus parent perceptions of child-level food security status via questionnaires within a large, ethnically diverse population. Previous approaches to alleviating food insecurity and providing nutritious foods, like vegetables, have focused on community or policy level barriers that these households may face. However, even when

these barriers have been overcome, individual and interpersonal barriers to vegetable availability, access, and utilization may still persist. The second aim was to examine the relationship between individual and interpersonal barriers to availability, access and utilization of vegetables and household food insecurity. The third aim was to examine the relationship between self-reported food insecurity and dietary quality. Research in this area was needed as evidence linking food insecurity to child dietary intake has been largely unclear and has utilized parent's perception of child-level food insecurity. The results of this research demonstrated the discordance that exists between child report and parent perceptions of child-level food insecurity and that additional research is needed in large, nationally representative samples. Further, within food-insecure households, significant barriers to access, availability, and utilization of vegetables were found. These barriers serve as ideal targets for future interventions seeking to improve vegetable consumption in low-income children. Lastly, food insecurity was associated with lower diet quality. Interventions targeting food insecure children are needed to improve dietary quality as this may alleviate some of the detrimental impacts of food insecurity on health and wellbeing.

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List of Abbreviations

AND	Academy of Nutrition and Dietetics
BMI	Body Mass Index
CFSA	Child Food Security Assessment
CPS	Current Population Survey
DGA	Dietary Guidelines for Americans
FI	Food Insecurity; food insecure
FRL	Free and Reduced-Price Lunch
HEI	Healthy Eating Index
HEI-2015	Healthy Eating Index-2015
HFSSM	Household Food Security Survey Module
NHANES	National Health and Nutrition Examination Survey
RDs	Registered Dietitian
SNAP	Supplemental Nutrition Assistance Program
US	United States
USDA	United States Department of Agriculture

CHAPTER 1: INTRODUCTION AND REVIEW OF LITERATURE

FOOD INSECURITY IN THE UNITED STATES

The United States Department of Agriculture (USDA) describes food security as "access by all people at all times to enough food for an active, healthy life".[1] Lack of the assured ability to acquire acceptable foods in socially acceptable ways is deemed food insecurity. Four labels are used by the USDA to describe the continuum of food security: (a) high food security, (b) marginal food security, (c) low food security, and (d) very low food security. The first two labels describe food security whereas, the latter two describe food insecurity. High food security represents that no problems, or anxiety about, consistently access adequate food were experienced within a reference time frame. On the other end of the spectrum and the most severe, very low food security represents that eating patterns were disrupted and food intake was reduced because of lack of money or other resources for food. Food insecurity can be temporary or chronic.[2,3]

As a result of the National Nutrition Monitoring and Related Research Act of 1990 (Public Law 101-445)[4] and since 1995, the United States (US) Census Bureau has conducted an annual food security survey,[5] as a supplement to the Current Population Survey (CPS).[6] A major impetus for this data collection is for monitoring and surveillance of trends within the population. Annual monitoring of the prevalence of food insecurity is also necessary for determining the effort and support needed by Federal nutrition assistance program and government and public health initiatives and interventions aimed at reducing food insecurity. In 2017, the survey collected data from over 37,000 households, comprising a nationally representative sample of over 127 million households.[1]

While CPS is the main survey for monitoring and surveillance of food insecurity trends in the US, food insecurity questions have also been added to other national surveys

such as the National Health and Nutrition Examination Survey (NHANES), the National Health Interview Survey (NHIS), the Early Childhood Longitudinal Survey (ECLS), among others.[6] The primary survey instrument used is the Household Food Security Survey Module (HFSSM) which was developed in 1995. Since 1995, the instrument has undergone minor revisions with the most recent revisions occurring in 2006 based on recommendations in a report from the Committee on National Statistics of the National Academies.[6,7] The HFSSM asks one adult respondent per household about experiences and behaviors that are indicative of food insecurity (ex: unable to afford balanced meals, hungry because of lack of money or resources for food, or cutting the size of meals to make food last longer).[1]

By the USDA's definition, 12% of all US households were food insecure in 2017.[1] Since 2000, the prevalence of food insecure has remained relatively unchanged with marginal increases and/or decreases from year to year. In 2011, during the most recent economic recession, the prevalence peaked at 14.9%, but has since gradually declined. Children are often thought to be shielded from the disrupted eating patterns and reduced food intake that make up low and very food insecurity; however, in 2017 7.7% of households with children were food insecure (approximately 2.9 million households.[1] Hispanic children are disproportionally affected by food insecurity. When comparing food insecurity among children, those from Hispanic households had a prevalence of 10.7% compared to the national average of all children. Only non-Hispanic Blacks have higher rates of food insecurity. Rates of food insecurity are also higher for those that are headed by a single parent and those with incomes near or below the Federal poverty line. Prevalence of food insecurity also varies considerably from state to state and geographic region.[1] The southern portion of the US historically has some of the highest rates of food

insecurity. In 2017, Texas had 14% of households with low food security and 5.8% of households with very low food security.[1]

Measurement of Food Insecurity in Children

More than two decades of qualitative research into how low-income people describe their food experiences and psychometric testing have produced good evidence of validity and reliability in the survey instruments used to measure household food insecurity.[8] When assessing household food insecurity, one adult who is usually the head of household that is most familiar with food purchasing and preparation, will complete a survey instrument to determine food insecurity status.

Parents are the most accurate reporters of the overall household food situation; however, parents cannot accurately or reliability report on what their children experience as they cannot fully understand how their child thinks and feels about particular experiences.[9] Although children and adults both experience household food insecurity, their experiences are quite different as a result of life-stage development and unique roles within the household.[10] Research has even found that food insecurity experiences and behaviors can differ within the household among siblings or spouses.[11] Differences in siblings may be a result of age, developmental stage, role in the family, or unique situation access to food resources outside of the home. Spouses may differ based on personal characteristics, priorities, choices, roles, expectations, or unique situation access to food resources outside of the home.

In addition to differing experiences and perspectives of food insecurity parents, particularly mothers, are often thought to shield or buffer their children from the effects of food insecurity but, research has shown that they may not always be able to fully protect their children.[10,12,13] This can result in parents underreporting food insecurity experiences on survey instruments. Parents have also been found to under-report socially undesirable

experiences in the fear that they may face stigma, shame, or involvement from social services.[10] Furthermore, children may hide their experiences from their parents or their experiences may go unnoticed by their parents as they may occur outside of the home.

Much of prior research into the conceptualization, assessment, and impact of child food insecurity has typically been derived from the mother's perspective as she is traditionally regarded as the primary food decision maker in the household. However, the use of parental or maternal report as a proxy for child reporting of child-level food insecurity is not always appropriate. When wanting to determine individual-level food insecurity, a child's report of their own food insecurity experiences is the most accurate.

In food insecurity research, child report is rarely used, especially before a child is 12 years old. However, in other areas of health research, child self-report is considered the "gold-standard" for assessing a child's internal experiences.[14,15] Research has shown that children as young as six are aware cognitively, emotionally, and physically of their food insecurity experiences, and are usually in a better position compared to their parents to accurately and reliably report about those experiences.[16,17]

It is important to note that while, children may experience and be aware of the presence and consequences of food insecurity, they may not be aware of its causes due to their limited understanding of household-level economics and barriers to access and availability of foods.[9] Therefore, children likely cannot accurately report on the overall household food situation. In this case, a parent's report of the overall household's food insecurity would be more accurate.

When comparing child versus parent perception of food insecurity experiences, the food security surveys that are administered to adults should not also be administered to children because they do not accurately measure children's experiences. Children have a unique and different conceptualization of food insecurity grounded in their own

experiences, their roles within their household, and in the ways they interact and make sense of their environments.[9] Therefore, specially developed questionnaires are needed when surveying children. Qualitative research has allowed researchers to gleam how children talk about their food insecurity experiences, the conceptualization of key domains and subdomains of those experiences (**Table 1),** and the development of tools to assess these the degree to which these food insecurity experiences occur.[10,18] One of the most commonly used instruments in children younger than 12 years is the Child Food Security Assessment (CFSA) developed by Maryah Fram.[18]

Table 1: Components of household food insecurity experienced by children

Domains & Subdomains	Description of Subdomain
Awareness of food insecurity	
Cognitive awareness	Children's knowledge that food is scarce, and their knowledge of ways that their family manages food problems
Emotional awareness	Feelings such as worry, sadness, or anger that are related to household food insecurity
Physical awareness	Physical feelings such as hunger, pain, tiredness, and weakness that are related to lack of sufficient food
Responsibility for managing food resources	
Participation with adult strategies	Active and cooperative involvement in adult-initiated strategies to make scarce food resources last
Initiation of strategies	Initiating strategies to make scarce food resources last
Generation of resources	Taking action to attain additional food or money for buying food

Adapted from Fram et al. 2011 *J. Nutr.*

Realizing the frequency of underreported or misclassification of child food insecurity by parents, existing research has focused on comparing child and parent report of child-level food insecurity. Several studies have reported notable discordance between reports from parents and children. Fram et al. found that parent report of child food

insecurity status can result in missing nearly half of children who report themselves as food insecure.[18] Previous studies have primarily focused on older child populations (>12 years).[19-21] Other studies have utilized younger child populations; however, these studies are limited in study sample size (<91 children).[18,22,23] All studies have reported that child-level food insecurity experiences are reported differently between a child and their parent.

Although it has been acknowledged that parent's report of child-level food insecurity results in underreporting or inaccurate estimates, national surveys continue to utilize only household food insecurity. While this does provide a measure of the home environment it does not capture individual experiences that individual family members may be having. There is a need for additional research in a large, multiethnic cohort to further demonstrate the discordance between child and parent reports and justify that in addition to collecting data on household food insecurity experiences, surveys should also collect data on understand food insecurity from the child's perspective. This research should also focus on the grey are in the literature, children that are younger than 12 years of age. Accurate conceptualization and measurement of food insecurity in children is a critical part of surveillance, monitoring, and public health efforts

ACCESS, AVAILABILITY, AND UTILIZATION OF FOODS WITHIN FOOD INSECURE HOUSEHOLDS

Food security involves the intersection of four food system domains or dimensions: availability, access, utilization, and stability.[2,24] These domains reflect the spectrum of factors that shape the food environment from macro to micro level influencers. **Figure 1** displays the four domains and simplifies rather complex relationships in the spectrum of factors that shape the food environment and encompasses macro to micro level influencers. Barriers to one of these domains can result in food insecurity experiences.

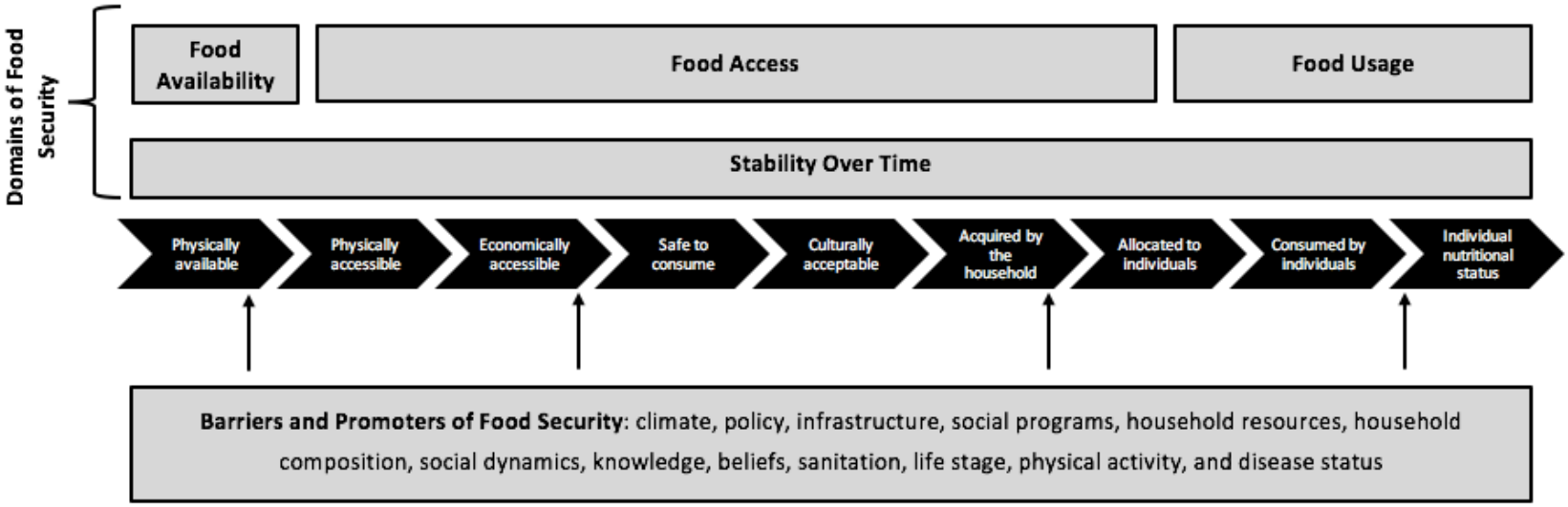

Figure 1: Domains of food security stemming from the food system environment and the barriers and promoters of food security. Adapted from Jones et al. 2013 *Adv Nutr*

Availability refers to the quality of foods being able to be obtained and consumed. *Access* is multidimensional and includes physical access to stores or other purchasing locations (farmer's markets or mobile markets), affordability and quality of available foods, and access to foods that are seasonally and culturally appropriate.[25] Food deserts represent areas characterized by poor access to healthy and affordable foods.[26] This area level deprivation of food is compounded when individual disadvantage, resulting from neighborhood factors, is considered.[27]

Predominantly minority neighborhoods, such as those comprising mostly Hispanic and non-Hispanic Blacks, are more likely to have lower grocery store access.[28] Low-income neighborhoods often lack full-service grocery stores and farmers' markets where individuals can purchase high quality, nutrient dense foods.[29] As a result, individuals may shop at small neighborhood convenience or corner stores where healthy foods – especially fresh produce – are often limited, of low quality, or of higher price.[26,30] Even when full-service stores are available, in-low income neighborhood healthier foods are often of poorer quality.[31] For this reason, some household may either not purchase these items or may go to a store that is farther away that offers items of higher quality.[32] When individuals do not use their own personal vehicles, and instead either walk or utilize public transportation, they may be constrained on how much they can purchase and carry. Lack of transportation options ultimately results in increased risk for food insecurity.[30]

Cost has consistently been found to be one of the most significant barriers to accessing and purchasing fresh produce for low-income indivudals.[33-36] Even when vegetables are available to purchase locally, research has found that low-income household would have to spend an unrealistic proportion of the household food budget to meet dietary guidelines.[34] Households with limited food budgets may be more likely to purchase cheap, energy-dense foods that are filling compared to healthier foods which may be more

expensive.[37-39] Previous research has found that food insecure households had lower consumption of healthier food items, particularly with regard to fruit and vegetable intake.[40] Research has shown that when healthier foods, such as vegetables, are available and accessible to a household to purchase and are available and accessible in the home, children have higher intakes of vegetables.[41-43] However, in some food insecure households, even when vegetables are physically available and physically and economically accessible, barriers in *utilization*, such as limited vegetable preparation knowledge and skills or perceived time constraints, can result in decreased consumption.[44]

Greater amount of time spent on home food preparation is associated with increased vegetable intake.[45] In the United States, cooking at home has increased within recent years,[46] and research has found that food insecure individuals have a similar frequency of cooking compared to their food secure peers.[47] However, it has been reported that meals in food insecure homes are less complex, which may be due to less time spent planning meals.[48] Lack of meal planning and cooking complexity may be a result of decreased food literacy. Food literacy encompasses the planning and management, selection, preparation, and consumption of foods.[49] A study by Begley and colleagues reported that limited food literacy was associated with greater food insecurity.[44] Research into the attitudes and self-efficacy towards cooking and the barriers that food insecure households face that result in decreased food literacy and utilization is needed.

While large community and policy driven initiatives have been developed to alleviate challenges and barriers to access, availability, and utilization that food insecure individuals may experience, initiatives and interventions conducted at the individual or interpersonal level could be more feasible.[50] More research is needed on the individual and interpersonal level barriers to the primarily food system domains of access, availability,

and utilization that food insecure individuals may face.[51] A greater understanding of these barriers would facilitate tailoring of future public health interventions.

FOOD INSECURITY AND HEALTH AND DIETARY INTAKE

There is a considerable amount of research demonstrating that low-income individuals are disproportionately impacted by adverse health outcomes.[52] During childhood, low-income children are more likely to experience food insecurity.[1,53] There is a growing awareness and acknowledgement of the adverse impact food insecurity can have on health and wellness. The literature has consistently found that food insecurity is associated with adverse health outcomes in children, including increased risk for anemia[54-56], asthma[57,58], aggression and anxiety[59], behavioral and social-emotional problems[60,61], mental health problems (depression, anxiety, suicidal ideation)[60,62-64], obesity[65,66], poor glycemic control[67], oral health problems[68], sedentary behaviors[17], and lower health status and health-related quality of life[61,69,70] compared with their food secure peers. Food insecurity has also been associated with children's educational performance and academic outcomes.[71]

Researchers have tried to explain the paradoxical relationship of food insecurity and obesity since it was first proposed by Dietz.[72] This association remains unclear as food insecurity is the result of inadequate resources to purchase foods thus potentially leading to decreased dietary intake and possibly weight loss and obesity is partially the result of excessive energy intake. There have been several attempts to provide hypothesis for this relationship including resource scarcity, stress, consumption of high calorie foods, or the impact of federal nutrition assistance programs[73-76]; however, overall, the relationship remains unclear.[40]

Because of the critical role nutrition plays in overall health and wellness and chronic disease development[77], prior to examining the relationships between food insecurity and health, there is a need to have a firm understanding of the association between dietary intake and food insecurity, especially in children. Because of limited time and resources, food insecurity may contribute to, or exacerbate, poor dietary intake; however, evidence linking food insecurity to child dietary intake is unclear.[78] A 2014 systematic review by Hanson and Connor examined 16 articles and 130 independent associations between food insecurity and components of dietary intake in children.[78] Of these, 16% suggested an adverse association, 3% suggested a beneficial relationship, and the remaining indicated a nonsignificant, ambiguous, or inconsequential association.

Most of the relationships reviewed by Hanson and Connor emphasized the relationship of single macronutrient, micronutrients, or individual foods or food groups in diet-food insecurity relationships.[78] More recently, researchers have focused less on the associations of individual nutrients or foods in isolation with disease risk and have examined a more inclusive approach to diet and health using dietary patterns.[79,80] Diet patterns focus on the synergy of nutrients within the context of total dietary intake, and can be used for assessing individual contributions of dietary components on health outcomes simultaneously.

One of the most common indices utilized in research is the Healthy Eating Index (HEI)[81,82], which measures adherence to the US Dietary Guidelines for Americans (DGA)[77] has been associated with numerous chronic diseases.[83] The HEI is appropriate for examining diet quality of the U.S. population as well as specific subgroups, such as children and adolescents, or racial-ethnic populations in a range of applications including epidemiology, population monitoring and surveillance, and nutrition interventions.[81] The HEI-2015 is based on thirteen components (total fruit, whole fruit, total vegetables, greens

and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, saturated fats, and added sugars) (**Figure 3**).[84] The first nine components are adequacy scores, with higher scores indicating higher consumption, and scores of zero indicating no intake. The remaining four components (refined grains, sodium, saturated fat, and added sugars) are components for moderation. Total fruit, whole fruit, total vegetables, greens and beans, total protein foods, seafood and plant proteins have a maximum score of five, and whole grains, dairy, fatty acids, refined grains, sodium, saturated fats, and added sugars which have a maximum score of 10. A total HEI score can be derived from adding up the 13 component scores. The maximum total HEI score is 100 and signifies the highest possible compliance to the DGA-2015.

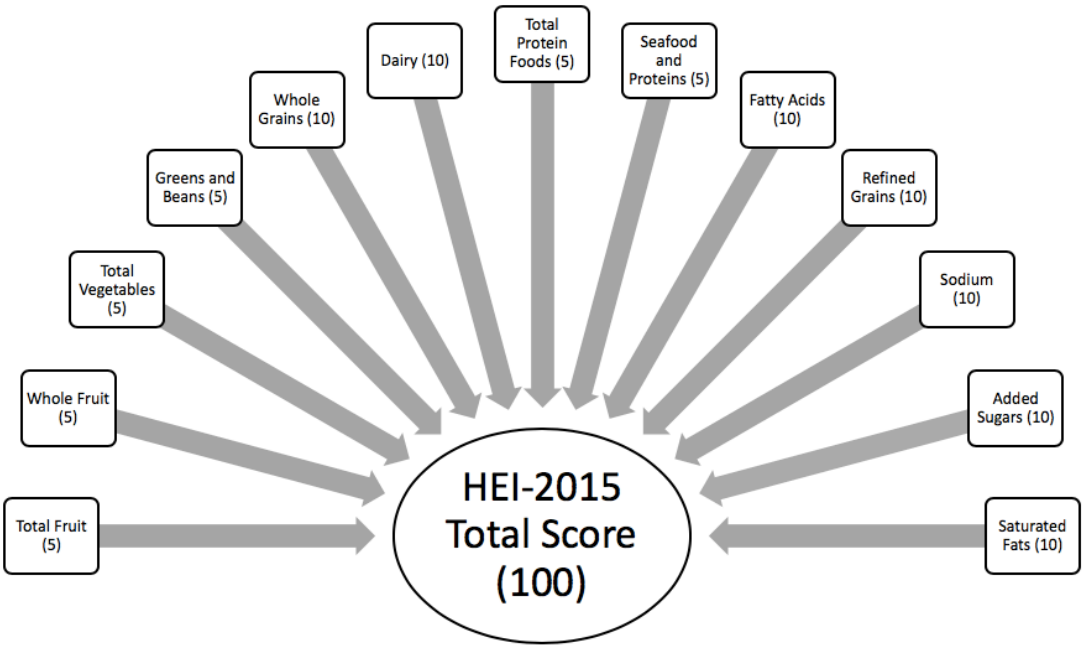

Figure 2: The Healthy Eating Index-2015 is a valid and reliable composite measure that helps assess overall diet quality and compliance with the Dietary Guidelines for Americans-2015

Research into the associations between overall diet quality and food insecurity in children are limited. Of the three studies included in the review by Hanson and Connor[78] that included measures of overall diet quality to examine the association with child food insecurity, results were split between adverse associations and no associations.[85-87] More recently, three studies have reported no association between dietary quality and child food insecurity.[17,88,89] Many of these studies had notable limitations including small or unrepresented samples, parent report of food insecurity, or inability to control for important confounding variables in the relationship between diet and food insecurity. Therefore, there is a need to better understand how food insecurity is associated with overall diet quality.

SUMMARY

Food insecurity remains a pervasive problem in the US. Ending child food insecurity requires a systematic approach through concentrated public health efforts. It is believed that food insecurity in children contributes to adverse health and may potentiate the development of chronic diseases.[76,90] There is a need for a greater understanding of how children perceive food insecurity experiences, the barriers that food insecure households face in availability, access, and utilization of foods, particularly nutrient dense vegetables. Based on the relationship between food insecurity and overall dietary quality, future programs and interventions can be developed and implemented.

SPECIFIC AIMS

The aims of this research are to: 1) To examine differences in perceptions of child-level food insecurity using the 8-item child-referenced USDA Household Food Security Survey Module (HFSSM) completed by parents compared to an adaption of the 5-item Child Food Security Assessment (CFSA) completed by children; 2) To examine the

relationship between individual and interpersonal barriers to availability, access and utilization of vegetables and household food insecurity; and 3) To examine the relationship between self-reported food insecurity and dietary quality in children (**Figure 3**).

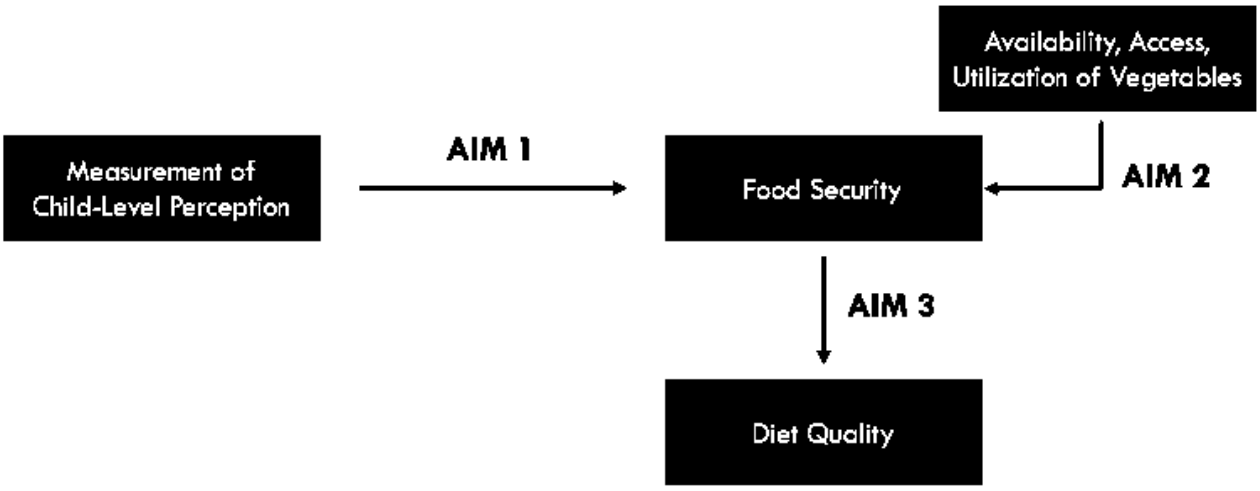

Figure 3: Overall summary of specific aims examining the associations between diet quality, vegetable availability and access, and food security in low-income children

CHAPTER 2: CHILD VERSUS PARENT PERCEPTIONS OF CHILD-LEVEL FOOD SECURITY

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Currently in review at *Current Developments in Nutrition*

ABSTRACT

There is a need to directly and accurately conceptualize and measure food insecurity in children as part of surveillance and public health efforts. The aim of this study was to compare parent versus child perceptions of child-level food security status via questionnaires within a large, ethnically diverse population. Cross-sectional baseline data from a cluster-randomized controlled trial involving primarily low-income, Hispanic 3rd-5th grade students and their parents was used for analysis. The sample consisted of 2408 dyadic (parent and child) pairs. Parents completed the 8-item child-referenced Household Food Security Survey Module and their responses were compared to an adaption of the 5-item Child Food Security Assessment completed by their child. Level of association between child and parent dyads perceptions were calculated using the Goodman and Kruskal's gamma statistic. The child sample was 53% female, had a mean age of 9 years, and were primarily Hispanic (63%). The parent sample was primarily female (86%) and Hispanic (65%). Child and parent perceptions of child-level food security agreed only 21.7% of the time There was a weak, positive association between child and parent perceptions of child-level food security (G = 0.162, p=<0.001). Children perceived themselves less food secure compared to their parent's perception 70.1% of the time. The results of this research, in combination with the existing literature, suggest that parent perceptions of child-level food insecurity may underestimate child-level food insecurity

experiences. Inaccurate or underestimations of the true prevalence of child-level food insecurity could be detrimental to maternal and child health efforts.

INTRODUCTION

The United States Department of Agriculture (USDA) describes food security as "access by all people at all times to enough food for an active, healthy life".[91] Lack of the assured ability to acquire acceptable foods in socially acceptable ways is deemed food insecurity. Four labels are used by the USDA to describe the continuum of household food security: (a) high food security, (b) marginal food security, (c) low food security, and (d) very low food security. The first two labels describe food security whereas, the latter two describe food insecurity. While 31.9 million (84.3%) United States (U.S.) households with children were food secure in 2017, nearly three million households with children (7.7%) were food insecure and 250,000 households (0.7%) experienced very low food security.[1]

Much of prior research into the conceptualization, assessment, and impact of child food insecurity has typically been derived from the mother's perspective as she is traditionally regarded as the primary food decision maker in the household. However, the use of parental or maternal report as a proxy for child reporting of child-level food insecurity is potentially inaccurate. Parents, particularly mothers, are often thought to shield or buffer their children from the effects of food insecurity but, research has shown that they may not always be able to fully protect their children.[10,12,13] Parents have been found to under-report socially undesirable experiences in the fear that they may face stigma, shame, or involvement from social services.[10] Furthermore, children may hide their experiences from their parents or their experiences with food may go unnoticed by their parents as these experiences often occur outside of the home where children may spend the bulk of their time. Research has shown that children as young as six are aware cognitively,

emotionally, and physically of their food insecurity experiences, and are usually in a better position compared to their parents to accurately and reliably report about those experiences.[16,17] Fram et al. found that parent-report of child food insecurity status can result in missing nearly half of children who report themselves as food insecure.[18]

Realizing the frequency of underreported or misclassification of child food insecurity by parents, existing research has focused on comparing child and parent report of child-level food insecurity. Several studies have reported notable discordance between reports from parents and children. Previous studies have primarily focused on older child populations (>12 years).[19-21] Other studies have utilized younger child populations; however, these studies are limited in study sample size (<91 children).[18,22,23] There is a need to understand food insecurity from a young child's perspective within a large, ethnically diverse population. The current study focuses on a large, multiethnic sample of children between the ages of 8-12. The aim of this study was to examine differences in perceptions of child-level food insecurity using an 8-item child-referenced USDA Household Food Security Survey Module (HFSSM) completed by parents compared to an adaption of the 5-item Child Food Security Assessment (CFSA) completed by children.

METHODS

Study Design: TX Sprouts

Cross-sectional, baseline data from TX Sprouts, a cluster randomized controlled trial, was used for analysis. TX Sprouts is a 1-year school based gardening, cooking, and nutrition program that targets over 3,000 3rd-5th grade students and their families from 16 elementary schools in the Austin area. Schools were randomized into one of three waves of data collection occurring between August 2016 and October 2018. Schools included in the trial had to meet the following inclusion criteria: 1) high proportion of Hispanic

children (>50%); 2) high proportion of children participating in the free and reduced lunch (FRL) program (>50%); and 3) location within 60 miles of The University of Texas at Austin campus. Full methods of the ongoing TX Sprouts intervention will be published elsewhere. The trial is registered at ClinicalTrials.gov (NCT02668744).

Recruitment of Children and Parents

All 3rd-5th grade students and parents at the recruited schools were contacted to participate via tables at "Back to School" and "Meet the Teacher" evenings events, flyers sent home with students, and teachers making class announcements.

Institutional Review Board

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Institutional Review Boards of The University of Texas at Austin and the individual school district review boards. Written informed consent was obtained from all parents, and assent from each student was obtained. Both consent and assent was required for inclusion in the study.

Data Collection

At baseline, both children and parents completed a 12-page questionnaire packet that included demographics and food security scales. Students completed all questionnaires during the school day at their respective schools as part of a larger data collection effort for TX Sprouts. Questionnaires were provided in both English and Spanish, and bilingual interpreters were available to assist students if needed. Parents completed take-home questionnaires that were provided in both English and Spanish and parents received a $15 gift card to a local grocery store as an incentive for completing the questionnaire.

Instruments Assessing Perceptions of Child-Level Food Insecurity

Child food security experiences were measured using a 5-item adapted version of the Child Food Security Assessment (CFSA), which was previously validated for use with children as young as six years.[17,18] One emotional subdomain item "I worry about how hard it is for parents to get enough food" included in the CFSA was removed and replaced with a child food management subdomain item "I tried not to eat a lot so that our food would last." This item tested well in previous validation assessments.[18] The items on the adapted CFSA represent four of six previously conceptualized subdomains of child food insecurity (Q1, emotional awareness; Q2-Q3, physical awareness; Q4, initiation of child food management strategies; Q5, cognitive awareness).[10] A reference frame of "in the last year" was used. Response categories were "a lot, sometimes, or never". The full questionnaire and response categories are listed in **Table 2.**

Responses to the CFSA were recoded as follows: "never" =0, "sometimes" =1, or "a lot" =2. Scores were summed to total between 0 and 10 with higher scores indicative of reporting decreased food security. Scores were distributed asymmetrically with a right skew. Four ordinal groups were created that corresponded with summed scores: 0 (high food security), 1 (marginal food security), 2 to 3 (low food security), and 4 to 10 (very low food security).

The adapted questionnaire's psychometric properties were assessed on a separate subsample of 65 3rd-5th grade students (45% male and ranged in age from 8-11 years with an average age of 9.5 years) Satisfactory Cronbach's alpha values were found for the five-item questionnaire (0.74), and removal of any item from the questionnaire lowered the scale's overall value. The students in the subsample were administered the adapted questionnaire twice, the second administration occurring three days after the first, for test-

retest reliability. There was a positive correlation (r_s=0.52) between time 1 and time 2 responses and an overall 82% agreement in food security classification.

Table 2: Percentage of child responses to the 5-Item adapted Child Food Security Assessment (n=2408)

In the last year, how often…	A Lot	Sometimes	Never
1. Did you worry about not having enough to eat?	14.2%	39.7%	46.1%
2. Did you feel hungry because there was not enough food to eat?	15.2%	37.5%	47.3%
3. Did you get really tired because there was not enough to eat?	11.5%	27.1%	61.4%
4. Did you try not to eat a lot so that your family's food would last?	16.8%	36.3%	46.8%
5. Did your family not get the food you wanted because there wasn't enough money?	10.7%	34.3%	54.9%

The parents of students completed the 8-item child-referenced questions of the HFSSM.[92] The child-referenced items included one screener question to confirm children in the household followed by seven items assessing children's food security experiences from the parent's perspective and make up the U.S. Children's Food Security Scale. Parent responses on the child-referenced items were recoded and summed in accordance with the USDA Economic Research Service recommendations.[92] The screener question included as part of the HFSSM was not included in the calculation of food security scores. Affirmative responses "a lot" and "sometimes" from the questionnaire were coded as "yes" = 1 while the negative responses "never" was coded as "no" =0. Scores were summed to total between 0 and 7 with higher scores indicative of reporting decreased food security. Scores were distributed asymmetrically with a left skew. Four ordinal groups were created that corresponded to summed scores: 0 (high food security), 1 (marginal food security), 2 to 4 (low food security), and 5 to 7 (very low food security).

Statistical Methods

For the comparison of child versus parent perception of food security, descriptive statistics (mean, standard deviation, number, percent) for household, child, and parent characteristics were calculated. Level of association between child and parent dyads was calculated using the Goodman and Kruskal's gamma statistic. The gamma statistic is a nonparametric measure of the strength and direction of association that exists between two variables measured on an ordinal scale.[93] An obtained value of +1 for gamma indicates the presence of a perfect correlation between the two variables. In contrast, an obtained value of -1 indicates the presence of a perfect negative correlation. A multiple linear regression model was used to determine if there was a significant interaction effect between child and parent perception of food security based on ethnicity, age of the child, and child gender. All analyses were completed using SPSS Statistics for Macintosh, Version 24.0 (IBM Corp, Armonk, NY) and an alpha level of p=0.05 was used for significance.

RESULTS

Of the 4239 eligible students at the 16 elementary schools, 3,303 children (78%) consented to be in the TX Sprouts study. Out of those consented children 3,137 (94%) completed baseline clinical measures and were included in the clinical trial. For this analysis, 2408 child and parent dyads (77%) had complete food security survey data. Household characteristics of child and parent dyads are recorded in **Table 3**. A majority of children reported receiving meals as part of the Free and Reduced Lunch Program (67%) and 34% of households received benefits from the Supplemental Nutrition Assistance Program. The child sample was 53% female, had a mean age of 9 years, and were primarily Hispanic (63%). The parent sample was primarily female (86%) and consisted of 98%

parents and 2% grandparents or another guardian. The parent sample was majority Hispanic (65%). Nearly half (42%) of the parent sample was born outside of the U.S.

Child and parent perceptions of child-level food security agreed only 21.7% of the time (**Table 4**). There was a weak, positive association between child and parent perceptions of child-level food security (G = 0.162, p=<0.001). Perceptions differed by one food security classification 26.7% of the time, differed by two categories 26.6% of the time, and differed by three categories 25.00% of the time. Children perceived themselves as being more food insecure compared to their parent's perception (parent underreport of severity) 70.1% of the time. Children perceived themselves as more food secure compared to their parent's perception (parent over-report of severity) 8.2% of the time.

A multiple linear regression model was used to predict child food security based on parent food security perception and tested the interaction effects for ethnicity, age, and child gender. This test did not show significant relationships ($p>0.05$) between the interaction of parent perception and ethnicity, age, and gender.

Table 3: Household characteristics and demographics of child and parent dyads (n=2408)

	Mean ± Standard Deviation or Number (Percentage)
Household Characteristics	
Number of children in the home	2.8 ±1.2
Number of adults in the home	1.7 ±1.0
Receive SNAP benefits	810 (33.6%)
Child Sample	
Age (years)	9.2 ±0.9
Gender	
Female	1281 (53.2%)
Ethnicity/Race[a]	
Non-Hispanic White	445 (18.5%)
Hispanic	1525 (63.3%)
Non-Hispanic Black	198 (8.2%)
Other[b]	120 (5.0%)
Undisclosed	120 (5.0%)
Participate in FRLP	1615 (67.1%)
Parental Sample	
Ethnicity/Race	
Non-Hispanic White	531(22.1%)
Hispanic	1554 (64.5%)
Non-Hispanic Black	190 (7.9%)
Other[b]	81 (3.4%)
Undisclosed	52 (2.2%)
Gender	
Female	2070 (86.0%)
Male	295 (12.3%)
Undisclosed	43 (1.8%)
Born Outside the US	1004 (41.7%)

Abbreviations: SNAP, Supplemental Nutrition Assistance Program; FRLP, Free and Reduced Lunch Program; US, United States.

[a]Response provided by the parent

[b]Other includes Asian, Pacific Islander, Native American, American Indian, or Other Ethnicity

Table 4: Agreement of parent (via 8-item child-referenced HFSSM) and child (via 5-item adapted CFSA) perceptions of child level food security status

Participant		Child				
	Level of Food Security	**High**	**Marginal**	**Low**	**Very Low**	**Total (n, %)**
Parent	**High**	335 (13.9%)	211 (8.8%)	422 (17.5%)	599 (24.9%)	1567 (65.10%)
	Marginal	61 (2.5%)	33 (1.4%)	76 (3.2%)	159 (6.6)	329 (13.7%)
	Low	56 (2.3%)	68 (2.8%)	125 (5.2%)	219 (9.1%)	468 (19.4%)
	Very Low	2 (0.1%)	6 (0.2%)	8 (0.3%)	28 (1.2%)	44 (1.8%)
	Total (n, %)	454 (18.9%)	318 (13.2%)	631 (26.2%)	1005 (41.7%)	2408 (100%)
				Percent Agreement[a]	21.7%	
				Gamma statistic (p-value)	$G = 0.162$ (<0.001)	

Abbreviations: HFSSM, Household Food Security Survey Module; CFSA, Child Food Security Assessment

[a]Percent agreement between parent and child perceptions calculated by summing totals in unshaded regions and dividing by the total sample.

DISCUSSION

The aim of this study was to compare parent versus child perceptions of child-level food security status via questionnaires. Parental and child dyad reports of child food insecurity had poor agreement when comparing responses on the 8-item child-referenced items of the HFSSM completed by parents, and the 5-item adapted CFSA completed by children. Additionally, 1686 children (70% of the sample) perceived more food insecurity experiences than their parents. Existing literature [18,20,23] in child populations <12 years have previously reported disagreement between parent and child report of child-level food security. The results of this study with its much larger multiethnic sample (2408 dyadic pairs), further corroborates the former findings of large discordance between dyad perceptions. Based on prior literature, these results suggest that parental report may be unrepresentative of actual child food insecurity experiences and if a parent proxy is used, prevalence of child-level food insecurity may be grossly underestimated.[18-20,23,94]

In other areas of health research, child self-report is considered the "gold-standard" for assessing a child's internal experiences.[14,15] Further, in many settings, having a validated questionnaire that can be administered directly to a child to measure their own reported food security status is advantageous when an adult proxy is not feasible or practical. Qualitative research in food insecure households has found that parents are not fully aware of the extent of a child's cognitive awareness to food insecurity experiences and are often even more unaware of a child's emotional or physical awareness.[94] Because of this, a parent's knowledge or their awareness of his/her children's experiences, exposure, and resource allocation can flaw parent report.

A common reason for discordance between parent and child reports of child-level food insecurity is that parents believe they are shielding their children from the effects of

food insecurity in their households. Shielding or buffering has been found to be multi-directional, extending from parent to child, parent to parent, child to child (especially older to younger), or child to parent, as well as taking different forms such as eating less so that someone else can eat more, or pretending not to be hungry.[95]

Unique to this study is the large, multiethnic sample population (2408 dyadic pairs; 4,816 total participants). Hispanics represent the nation's largest ethnic minority comprising 17.6% of the total population and are the fastest growing ethnic group.[96] This quickly growing population is disproportionally affected by poverty and food insecurity and is at increased risk for being obese and developing type 2 diabetes.[1,97,98] There is an urgent need to better understand food insecurity and its effects within this population to lessen the burden of health disparities. This study also highlights the extent to which underreporting of child-level food security may occur within a multiethnic, at-risk population.

This study found that child and parent perceptions of child-level food security were not in agreement and children perceived more food insecure experiences. This study did not address which report, child or parent, was more accurate of children's actual food-related experiences. However, child report of their food security experiences has been previously shown to be substantially more accurate, based on the work of Fram et al. 2013, which developed a definitive measure to which the child and parent questionnaire-based measures could be compared.[18] Therefore, the interpretation of results from this study with a large, multiethnic cohort only further corroborates an existing problem in accurately measuring child-related food insecurity. A limitation of this study is that a child's report of his/her individual experiences and food security status was assessed, which may not be reflective of other children in the household. Further research should elect to measure agreement of perceptions between children within the same household.

CONCLUSION

There is a need to directly and accurately conceptualize and measure food insecurity in children as part of surveillance and monitoring efforts. The results of this research in combination with the existing literature suggest that parent perceptions of child-level food insecurity may underestimate child-level food insecurity experiences. Ending child food insecurity requires a systematic approach through concentrated public health efforts. Reliable and accurate measurement of child food insecurity begins with a grounded understanding that children's experiences with food security are different than their parents. Inaccurate or underestimations of the true prevalence of child-level food insecurity could be detrimental to public health efforts.

CHAPTER 3: VEGETABLE AVAILABILITY, ACCESS, AND UTILIZATION WITHIN FOOD SECURE AND INSECURE, MULTIETHNIC HOUSEHOLDS IN CENTRAL TEXAS

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Currently in review at *The Journal of the Academy of Nutrition and Dietetics*

ABSTRACT

A better understanding of the barriers that food insecure (FI) households face in regards to availability, access, and utilization of vegetables is warranted to help facilitate the tailoring of future public health interventions and nutrition education. The objective was to examine the relationship between availability and barriers to access and utilization of vegetables and household FI. This was a cross-sectional baseline study that analyzed self-reported data from parents of children in TX Sprouts, a cluster-randomized school-based gardening, cooking, and nutrition intervention. Availability of vegetables and barriers to access and utilization of vegetables within the home were self-reported via questionnaires. Food security status was assessed using the 18-item Household Food Security Survey Module. Data were available on 1891 parents and included the following demographics: 87% female, 63% Hispanic, and 27% reported household FI. Main outcome measures were self-reported availability of vegetables and barriers to access and utilization of vegetables and household FI. Binomial logistic regressions were used to investigate the relationship of availability of vegetables and perceived barriers to access and utilization of vegetables and household FI. Compared to individuals who *always* had fresh vegetables in the home, individuals who *never*, *some of the time*, and *most of the time* had fresh vegetables were more likely to be FI. Two barriers to vegetable access (vegetables being too expensive and

being unable to find quality vegetables) were associated with increased odds of being FI and four barriers to utilization (hard to use before spoilage, no time for preparation, don't know simple, easy recipes, and family not helping with cooking) were associated with increased odds of being FI. This study identified barriers to vegetable consumption in FI households that can be addressed through targeted, multi-context or multi-level public health intervention.

INTRODUCTION

The 2015-2020 Dietary Guidelines for Americans recommends that Americans consume more vegetables as part of an overall healthy dietary pattern.[77] Consumption of a diet rich in vegetables can protect against diet-related chronic diseases including heart disease, type 2 diabetes, obesity, and some cancers.[77] Despite the established health benefits, only 13% of Americans age one and older meet the vegetable recommendations.[77] Children and young adolescents, in particular, vegetable consumption falls well below recommended intakes.[77]

Parents and other caregivers exert considerable control over the foods that younger children eat; even as adolescents gain greater autonomy over their dietary choices, the home environment plays a significant role in dietary intake.[99-101] Numerous demographic, psychosocial, behavioral, and socio-environmental factors have been identified as correlates of vegetables consumption within children.[102-107] Higher vegetable consumption during childhood is associated with healthier eating behaviors over a lifetime;[108] therefore, research identifying ways to promote vegetable consumption during childhood is warranted.

There is a direct correlation between food insecurity in households and decreased intake of vegetables in children.[17,43,104] The US Department of Agriculture (USDA)

describes food security as "access by all people at all times to enough food for an active, healthy life".[91] Lack of the assured ability to acquire acceptable foods in socially acceptable ways is deemed as food insecurity. Food security involves the intersection of four food system domains or dimensions: availability, access, utilization, and stability.[2,24] Food insecure households may experience increased barriers to one of these domains that in turn impacts purchase decisions and dietary consumption.

Vegetable *availability* refers to the quality of being able to be obtained and consumed. Vegetable *access* is multidimensional and includes physical access to stores or other purchasing locations (farmer's markets or mobile markets), affordability and quality of available produce, and access to vegetables that are seasonally and culturally appropriate.[25] Research has shown that when healthier foods, such as vegetables, are available and accessible to a household to purchase and are available and accessible in the home, children have higher intakes of vegetables.[41-43] However, in some food insecure households, even when vegetables are physically available and physically and economically accessible, barriers in *utilization*, such as limited vegetable preparation knowledge and skills or perceived time constraints, can result in decreased consumption.[44] A greater understanding of the barriers to availability, access, and utilization of vegetables that lead to decreased consumption, particularly in food secure and food insecure households, is needed. Knowledge of how barriers both outside and inside of the home environment perpetuate food insecurity would facilitate tailoring of future public health interventions.

This study aimed to examine availability, access, and utilization of vegetables within a household and the odds of being food insecure. It was hypothesized that decreased availability and increased barriers to access and utilization of vegetables within a household would be associated with greater odds of being food insecure. This study also

aimed to identify which barriers were the most common within food insecure households and would therefore be ideal targets for future public health interventions.

MATERIALS AND METHODS

Description of Study

Cross-sectional parent data from TX Sprouts, a cluster-randomized school-based gardening, cooking, and nutrition intervention were used. TX Sprouts targeted 3rd-5th grade students and their parents from 16 elementary schools in the Austin area. An aim of the intervention was to improve vegetable intake through improvements in vegetable availability, access, and utilization. Schools were randomized into one of three waves of data collection occurring between August 2016 and October 2018. Schools included in the trial had to meet the following inclusion criteria: 1) high proportion of Hispanic children (>50%); 2) high proportion of children participating in the free and reduced lunch (FRL) program (>50%); 3) located within 60 miles of The University of Texas at Austin campus, and 4) no existing garden or gardening program. The trial is registered at ClinicalTrials.gov (NCT02668744).

Recruitment

All 3rd-5th grade students and parents at the recruited schools were contacted to participate via information tables at “Back to School” and “Meet the Teacher” evenings events, flyers sent home with students, and teachers making class announcements.

Institutional Review Board

Written informed consent was obtained from all parents, and assent from each student. Both consent and assent were required for inclusion in the study. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all

procedures involving human subjects were approved by the Institutional Review Boards of The University of Texas at Austin and the individual school district review boards.

Data Collection

At baseline, parents completed a 12-page self-administered questionnaire packet that included demographics and food security scales. Questionnaires were completed either at "Back to School" or "Meet the Teacher" evening events or sent home with student, completed by a parent, and returned to school with the student. Questionnaires were provided in both English and Spanish. Items about demographics, food and meal choice behaviors, barriers to healthy eating habits, and household food security were included the questionnaires. Parents received a $15 gift card to a local grocery store as an incentive for completing the questionnaire.

Assessment of Food Security Status

Data on food security status were collected using the USDA's 18-item Household Food Security Survey Module.[92] Following USDA procedure to calculate a participant's food security status, the number of affirmative answers were counted. An affirmative answer included answering "yes," "often," "sometimes," "almost every month," or "some months but not every month". The total number of affirmatives was a respondent's raw score. Food security status was categorized as food secure (raw score 0-2) or food insecure (raw score 3-18) and analyzed as a dichotomous variable.

Vegetable Availability, Access, and Utilization

Items assessing availability, access, and utilization were adapted from items used in a similar school-based gardening intervention by Evans and colleagues.[109] Availability of four vegetable types were assessed (fresh; canned, dried and frozen; salad; and cut-up

vegetables within easy reach). Three items assessed access to vegetables (example: The stores near me do not sell fresh vegetables) and six items assessed utilization of vegetables (example: I don't know how to prepare vegetables). Full questionnaire items and response options are provided in **Table 5**.

Covariates

Ethnicity (non-Hispanic White; non-Hispanic Black; Hispanic; and other), education (less than a high school diploma; high school diploma; greater than a high school diploma), and participation in the Supplemental Nutrition Assistance Program (SNAP) (yes or no) were self-reported.

Statistical Analysis

Three binomial logistic regressions were used to investigate the relationship between vegetable availability and perceived barriers to vegetable access and utilization and household food insecurity while controlling for ethnicity, educational attainment, and SNAP participation. Food insecurity was selected as the outcome variable as future analyses will investigate the intention-to-treat effects of the TX Sprouts intervention on food insecurity. Separate models were used to examine the independent relationships of each domain (availability, access, and utilization) of food security independently. All analyses were conducted using SPSS Statistics for Macintosh, Version 24.0 (IBM Corp, Armonk, NY) and an alpha level of p=0.05 was used for significance.

Table 5: Questionnaire items included in TX Sprouts parent questionnaire assessing availability, access, and utilization of vegetables

Food Security Domain	Questionnaire Items	Response Options
Availability	*What foods were available in your home last week?* • Fresh vegetables • Canned, frozen, or dried vegetables • Salad • Cut up fresh vegetables in a place that is easy for kids to reach	○ All of the Time ○ Most of the Time ○ Some of the Time ○ Never
Access	*Do you experience any of the following challenges when buying vegetables for meals in your home?* • Vegetables are too expensive • I can't find quality vegetables • The stores near me do not sell fresh vegetables	○ Yes ○ No
Utilization	*Do you experience any of the following challenges when preparing or cooking vegetables in your home?* • It's hard to use fresh vegetables before they spoil • My family doesn't like vegetables • I don't have time to prepare vegetables • I don't know how to prepare vegetables • I don't have simple and quick recipes • My family doesn't help me cook	○ Yes ○ No

Questionnaire items were adapted from those used by Evans A, Ranjit N, Hoelscher D, et al. Impact of school-based vegetable garden and physical activity coordinated health interventions on weight status and weight-related behaviors of ethnically diverse, low-income students: Study design and baseline data of the Texas, Grow! Eat! Go!(TGEG) cluster-randomized controlled trial. *BMC Public Health.* 2016;16(1):973.

RESULTS

Study Sample

Of the 4,239 eligible students at the 16 elementary schools, 3,303 children (78%) consented to be in the TX Sprouts study. Out of those consented children, 3,137 (95%) completed baseline clinical measures and were included in the clinical trial. For this analysis, only parent survey data of children in the clinical trial was used. Of the children included in the clinical trial, 2,873 (92%) parents returned baseline surveys. The final analytic sample consisted of 1,891 parent respondents after elimination of cases with missing survey data for the dependent variable (food security) (n=726), the independent variables (n=168), and confounding demographic variables (n=88). There were no significant differences in the demographic variables between respondents with complete or missing data for independent and dependent variables.

The analytic parent sample was predominantly female (87%) and primarily Hispanic (63%). Other races/ethnicities comprising the sample were non-Hispanic white, 25%; non-Hispanic Black, 9%; and other, 3%. A child's mother or father was the primary questionnaire respondent (98%); other respondents were grandparents (2%) or other guardians (<0.5%). Twenty seven percent (514 of 1,891) of the sample reported household food insecurity. Thirty-seven percent of the respondents had less than a high school diploma, 20% had a high school diploma, and 43% attained greater than a high school diploma. Thirty-three percent of the sample reported receiving SNAP benefits.

In all three logistic regression models - availability, access, and utilization - both SNAP participation and education were significant confounding predictors for greater odds of being food insecure versus food secure **(Tables 6-8)**. SNAP participants were associated with greater odds of being food insecure. Compared to having a high

school diploma, those without had greater odds of being food insecure. Ethnicity/race, with Hispanic as the referent, was not significantly associated with odds of being food insecure.

Availability of Vegetables

Compared to those that *always* had fresh vegetables in the home, those that *never*, *some of the time*, and *most of the time* had fresh vegetables had a 4.26, 3.53, and 1.64 greater odds of being food insecure versus food secure, respectively (**Table 6**). The availability of cut-up vegetables within easy reach was not associated with food insecurity. With *always* as the referent, availability of salad was not associated with food insecurity; however, when *never* was used as the referent, there was a significant pairwise relationship between *never* and *most of the time* response categories. There were no significant differences for availability of salad and food insecurity status.

Barriers to Vegetable Access

Individuals who find vegetables too expensive compared to those who do not had seven-fold greater odds of being food insecure (**Table 7**). Respondents who reported being unable to find quality vegetables at the store had two times greater odds of being food insecure. The barrier of stores not selling fresh vegetables was not a significant predictor for food security status.

Table 6: Binomial logistic regression of vegetable availability on the prevalence of household food insecurity

Parameter	Odds Ratio	95% CI	P-value
SNAP Participation	1.41	1.12, 1.79	0.004**
Education			<0.000***
High School Diploma	Referent	---	---
< High School Diploma	1.97	1.45, 2.68	<0.001***
> High School Diploma	0.90	0.66, 1.22	0.489
Ethnicity/Race			0.814
Hispanic	Referent	---	---
Non-Hispanic White	0.93	0.68, 1.26	0.632
Non-Hispanic Black	1.15	0.77, 1.72	0.510
Other[a]	0.95	0.51, 1.76	0.876
Availability of Fresh Vegetables			<0.001***
Always	Referent	---	---
Most of the Time	1.64	1.20, 2.26	0.002**
Some of the Time	3.53	2.41, 5.17	<0.001***
Never	4.26	2.13, 8.52	<0.001***
Availability of Canned, Frozen, or Dried Vegetables			0.137
Always	Referent	---	---
Most of the Time	1.37	1.02, 1.86	0.040*
Some of the Time	1.03	0.75, 1.42	0.867
Never	1.23	0.85, 1.78	0.269
Availability of Salad			0.009**
Always	Referent	---	---
Most of the Time	0.81	0.57, 1.12	0.244
Some of the Time	1.34	0.94, 1.91	0.107
Never	1.40	0.80, 2.45	0.239
Availability of Cut Up Vegetables within Easy Reach			0.617
Always	Referent	---	---
Most of the Time	1.26	0.89, 1.78	0.603
Some of the Time	1.12	0.77, 1.61	0.561
Never	1.12	0.73, 1.74	0.191

*p<0.05; **p<0.01; ***p<0.001

Abbreviations: SNAP, Supplemental Nutrition Assistance Program

[a]Other includes survey responses of Native American, Asian, or Other

Table 7: Binomial logistic regression of barriers to vegetable access on the prevalence of household food insecurity

Parameter	Odds Ratio	95% CI	P-value
SNAP Participation	1.56	1.23, 2.00	<0.001***
Education			<0.001***
High School Diploma	Referent	---	---
< High School Diploma	1.81	1.32, 2.48	<0.001***
> High School Diploma	0.79	0.57, 1.08	0.137
Ethnicity/Race			0.569
Hispanic	Referent	---	---
Non-Hispanic White	1.09	0.80, 1.49	0.582
Non-Hispanic Black	1.34	0.89, 2.04	0.163
Other[a]	1.00	0.52, 1.91	0.999
Barriers to Vegetable Access[b]			
Vegetables are Too Expensive	7.34	5.66, 9.52	<0.001***
Can't Find Quality Vegetables	2.00	1.36, 2.93	<0.001***
Stores Don't Sell Fresh Vegetables	1.40	0.66, 2.95	0.382

*p<0.05; **p<0.01; ***p<0.001
Abbreviations: SNAP, Supplemental Nutrition Assistance Program
[a]Other includes survey responses of Native American, Asian, or Other
[b]Response options to challenge survey questions were dichotomous "yes" or "no"

Barriers to Vegetable Utilization

From the model, not having time for preparation was associated with two-fold greater odds of being food insecure (**Table 8**). Parents who reported the barriers of vegetables being hard to use before spoiling, not knowing simple, easy recipes, and not having assistance in cooking from other family members also had 1.6, 1.9 and 1.9 greater odds of food insecurity, respectively, compared to parents not reporting experiencing that barrier. The barriers of family members not liking vegetables and not knowing how to prepare vegetables were not associated with greater odds of being food insecure.

Table 8: Binomial logistic regression of barriers to vegetable utilization on the prevalence of household food insecurity

Parameter	Odds Ratio	95% CI	P-value
SNAP Participation	1.53	1.22, 1.93	<0.001***
Education			<0.001***
High School Diploma	Referent	---	---
< High School Diploma	1.91	1.42, 2.57	<0.001***
> High School Diploma	0.79	0.58, 1.07	0.133
Ethnicity/Race			0.392
Hispanic	Referent	---	---
Non-Hispanic White	0.92	0.68, 1.24	0.597
Non-Hispanic Black	1.23	0.88, 1.92	0.190
Other[a]	1.24	0.68, 2.27	0.490
Barriers to Vegetable Utilization[b]			
Hard to Use Before Spoilage	1.57	1.17, 2.11	0.003**
Family Doesn't Like Vegetables	1.07	0.79, 1.46	0.665
No Time for Preparation	2.24	1.31, 3.83	0.003**
Don't Know How to Prepare	1.20	0.79, 1.84	0.393
Don't Know Simple, Easy Recipes	1.91	1.42, 2.57	<0.001***
Family Doesn't Help Cook	1.92	1.19, 3.08	0.007**

*p<0.05; **p<0.01; ***p<0.001
Abbreviations: SNAP, Supplemental Nutrition Assistance Program
[a]Other includes survey responses of Native American, Asian, or Other
[b]Response options to challenge survey questions were dichotomous "yes" or "no"

DISCUSSION

This study assessed relationships between availability, and barriers to access and utilization of vegetables and household food insecurity. Decreased availability of fresh vegetables and increased barriers to access (vegetables being too expensive and being unable to find quality vegetables) and utilization (hard to use before spoilage, no time for preparation, not knowing simple, easy recipes, and family not helping with cooking) were associated with greater odds of being food insecure. While previous studies have typically

examined the food system domains[2] of availability, access, and utilization of vegetables within low-income households independently, this study examined all three within our population. Furthermore, while food insecurity and poverty are highly correlated, these statuses are not synonymous.[110] This study adds to our understanding of the barriers that food insecure households face. The authors hope to use this information to later assess the intention-to-treat effects of the TX Sprouts intervention on food security mediated through improvements in availability, access, and utilization of vegetables.

This study controlled for confounding factors such as participation in federal nutrition assistance programs such as the SNAP, which aims to lessen the burden of food insecurity.[111] Therefore, the barriers found in this study that were significantly associated with food insecurity go above and beyond the protection of this assistance program. Education level of the questionnaire respondent was also controlled for in analyses, as vegetable consumption has been shown to vary by level of education and those with higher educational attainment have been associated with having higher household incomes and are less likely to be food insecure.[1,112]

Availability

Home availability of vegetables is a topic of interest as the home plays a central role in influencing child dietary consumption and may serve as a modifiable target for interventions. There has been evidence that absence of home availability of vegetables results in greater intake of vegetables in children.[42] Much of the research has focused on low-income households, but there is a lack of research within food insecure households. This study found a significant association between the availability of fresh vegetables and food security. This relationship was found for fresh vegetables and was not seen with other types of vegetables. Although availability of vegetables does not guarantee consumption,

children within food insecure households may have decreased intake of vegetables compared to their food secure peers because of reduced availability. However, research by Poulsen and colleagues found that food security status was not associated with vegetable consumption.[43] Further research is needed to determine the relationship between home vegetable availability and intake within food insecure children.

Access

This study found a relationship between cost of vegetables and food insecurity. Cost has been consistently found to be a major barrier to accessing and purchasing fresh vegetables for low-income indivudals.[33-36] Even when vegetables are available to purchase locally, research has found that low-income household would have to spend an unrealistic proportion of the household food budget to meet dietary guidelines.[34]

Within this study, participants reported that local stores not selling fresh vegetables was not a significant barrier; however, finding quality vegetables was a significant barrier. Qualitative research has reported that low-income households may avoid purchasing vegetables even when available because of the lack of high-quality options.[35,113] Efforts to increase access to fresh produce have resulted in a growing number of vegetable access programs. These programs may provide a means of accessing fresher and better-quality vegetables for low-income and food insecure households compared to traditional grocery stores. Community gardens[114-116] and farmers' markets,[117-119] especially those that accept food assistance benefits, have been shown to increase food security and vegetable intake. These programs are most likely to succeed when they simultaneously address multiple barriers to access or when coupled with other interventions or strategies.[35]

Utilization

The utilization domain of food security has traditionally been overlooked as research has focused on community or policy level barriers to vegetable availability and access. Assuming vegetables are available and accessible within a household, utilization incorporates all household practices and individual behaviors in the transformation of food into meals including planning, management, selection of foods, preparation and cooking skills.[2,24] In this study, difficulties using fresh vegetables before they spoil, not having time to prepare vegetables, and not having simple quick recipes were found to be significant barriers to utilization in food insecure households. These barriers encompass aspects tied to food literacy (practical food knowledge and skills).[49]

Greater amount of time spent on home food preparation is associated with increased vegetable intake.[45] In the United States, cooking at home has increased within recent years,[46] and research has found that food insecure individuals have a similar frequency of cooking compared to their food secure peers.[47] However, it has been reported that meals in food insecure homes are less complex, which may be due to less time spent planning meals.[48] Lack of meal planning and cooking complexity may be a result of decreased food literacy. A study by Begley and colleagues reported that limited food literacy was associated with greater food insecurity.[44] Food literacy is a targetable outcome for nutrition education, as it can improve through education and skill development.[120]

The barrier of not having assistance from family members in meal preparation was also identified with increased odds of being food insecure within this population. Prior research has shown that children involved in cooking activities have higher vegetable intake compared to children who do not help.[121-123] Educating parents on successful ways to utilize their child's help coupled with equipping children with basic cooking skills may be a potential strategy to overcome this barrier.

Limitations

This study has several limitations. First, because of the cross-sectional design, only associations, not causal relationships can be inferred. This study used parents' report of household vegetable availability, which could be seen as a potential limitation, as there is evidence suggesting that a child's perception of availability is more likely to be associated with their own intake of vegetables.[42] This study focused on the barriers from store to household that are present within food insecure households. These challenges are most likely not unique only to our study's population. However, a firm understanding of unique or different population-specific determinants and barriers to intake that may exist is required when developing tailored interventions. Other demographic, psychosocial, behavioral, and socio-environmental factors may influence this relationship and be critical in guiding future public health efforts.

CONCLUSION

Registered dietitians and nutritionists possess the education and competency to make valuable contributions to improving availability, access, and utilization of vegetables within food insecure populations.[124] The barriers to availability, access, and utilization of vegetables that were associated with household food insecurity are ideal targets for future interventions seeking to improve vegetable consumption in low-income children. The results of this study can be used to develop public health interventions that address the areas in which low-income minority households experience the most significant barriers that limit vegetable consumption.

CHAPTER 4: CHILD-REPORT OF FOOD INSECURITY IS ASSOCIATED WITH DIET QUALITY IN CHILDREN

Landry MJ, van den Berg AE, Asigbee FM, Vandyousefi S, Ghaddar R, Davis JN. Child-Report of Food Insecurity Is Associated with Diet Quality in Children. *Nutrients*. 2019;11(7):1574.

Conceptualization, MJL; data curation, MJL, AEvdB, FMA, SV, RG and JND; formal analysis, MJL; funding acquisition, JND; project administration, AEvdB and JND; writing–original draft, MJL; writing–review/editing, MJL, AEvdB, FMA, SV and RG

ABSTRACT

Food insecurity (FI) is adversely associated with physical and mental wellbeing in children. The mechanism underlying this association is assumed to be dietary intake; however, evidence has been mixed. This study examined the relationship between self-reported FI and dietary quality among low-income children. Cross-sectional data were used from TX Sprouts, a school-based cooking, gardening, and nutrition intervention. A sample of 598 children completed two 24-h dietary recalls and a questionnaire including an adapted version of the 5-item Child Food Security Assessment (CFSA). Food security was categorized as food secure or FI based on summed CFSA scores. Dietary quality was assessed using the Health Eating Index-2015 (HEI-2015). Mixed effects linear regression models examined associations between FI and dietary quality. Children were 64% Hispanic, 55% female, and were 9.2 years old on average. Adjusting for sociodemographic characteristics, BMI percentile, and energy intake, FI was associated with lower HEI-2015 total scores ($\beta = -3.17$; 95% CI = −5.28, −1.06; $p = 0.003$). Compared to food secure children, FI children had lower greens and beans (2.3 vs. 1.9, $p = 0.016$), seafood and plant protein (2.0 vs. 1.6, $p = 0.006$), and added sugar (7.4 vs. 8.0, $p = 0.002$) component scores. Interventions targeting low-income and FI children should investigate ways to improve dietary quality.

INTRODUCTION

In 2017, children in 7.7% of United States (U.S.) households (approximately 2.9 million households) lived within food-insecure households, meaning that their household access to adequate food was limited by a lack of money and other resources.[1] The health consequences of child food insecurity are well documented.[90] The mechanism that underlies food insecurity contributing to poor health is assumed to be unhealthy dietary intake. Because of limited time and resources, food insecurity may contribute to, or exacerbate, poor dietary intake; however, evidence linking food insecurity to child dietary intake is unclear.[78,125]

A 2014 systematic review by Hanson and Connor examined 16 articles and 130 associations between food insecurity and dietary intake in children.[78] Of the 130 associations, 16% suggested an adverse association, 3% suggested a beneficial relationship, and the remaining indicated a nonsignificant, ambiguous, or inconsequential association. These studies primarily emphasized the relationship of single macronutrient, micronutrients, or individual foods or food groups in diet-food insecurity relationships. More recently, researchers have focused less on the associations of individual nutrients or foods in isolation with disease risk and have examined a more inclusive approach to diet and health using dietary patterns.[79,80] Diet patterns focus on the synergy of nutrients within the context of total dietary intake, and can be used for assessing individual contributions of dietary components on health outcomes simultaneously. Dietary indices such as the Healthy Eating Index (HEI)[81], which measures adherence to the U.S. Dietary Guidelines for Americans (DGA), have been associated with numerous chronic diseases.[83]

Of the three studies that included measures of overall diet quality to examine the association with child food insecurity, results were split between adverse associations and no associations.[85-87] More recently, three studies reported no association between dietary

quality and child food insecurity.[17,88,89] A limitation of nearly all previously mentioned studies examining the relationship between food insecurity and dietary quality is the use of parent-reported household food insecurity.[78] Consistently, research has shown that parental report of child-level food insecurity may be unrepresentative of actual child food insecurity experiences and if a parent proxy is used, prevalence of child-level food insecurity may be grossly underestimated.[18-20,23,94] The two studies that have used child self-report of their own food security experiences to examine associations between dietary quality and food insecurity have found no association.[17,88] However, these studies were limited in that they utilized a geographically limited sample and did not control for body weight or body mass index (BMI) as a potential confounding variable.[17,88]

The present study sought to use a child's report of their food insecurity experiences to examine the relationship between food insecurity and dietary quality in a multiethnic cohort of children (7–13 years of age). Food insecurity disproportionally impacts non-Hispanic Blacks and Hispanics compared to non-Hispanic Whites.[1] Whereas previous studies have stratified their sample based on *a priori* hypotheses of demographic differences, this study sought to examine the interaction between sex and ethnicity/race and food insecurity prior to stratification.

MATERIALS AND METHODS

Description of Study

Cross-sectional baseline data from TX Sprouts, a cluster-randomized school-based gardening, cooking, and nutrition intervention, were used. TX Sprouts targeted 3rd-5th grade students and their parents from 16 elementary schools in the Austin area. Schools were randomized into one of three waves of data collection occurring between August 2016 and October 2018. Schools included in the trial had to meet the following inclusion criteria:

1) high proportion of Hispanic children (>50%); 2) high proportion of children participating in the free and reduced lunch (FRL) program (>50%); 3) location within 60 miles of The University of Texas at Austin campus; and 4) no previous or existing gardening program. Based on these criteria, 73 schools were invited to participate, and 20 schools from five different independent school districts agreed to participate. The first 16 out of the 20 schools to provide letters of support were randomly assigned to either intervention (n=8 schools) or control group (delayed intervention; n=8 schools). Full methods of the ongoing TX Sprouts intervention will be published elsewhere. The trial is registered at ClinicalTrials.gov (NCT02668744).

Study Recruitment

All 3rd-5th grade students and parents at the recruited schools were contacted to participate via tables at "Back to School" and "Meet the Teacher" evenings events, flyers sent home with students, and teachers making class announcements.

Institutional Review Board

Written informed consent was obtained from all parents, and assent from each student was obtained. Both consent and assent were required for inclusion in the study. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Institutional Review Boards of The University of Texas at Austin and the individual school district review boards.

Data Collection

At baseline, children completed a 12-page questionnaire packet that included items about demographics and a food security scale. Students completed all questionnaires

during the school day at their respective schools as part of a larger data collection effort for TX Sprouts. Questionnaires were provided in both English and Spanish, and bilingual interpreters were available to assist students if needed. Parents completed a separate 12-page self-administered questionnaire that was provided in both English and Spanish. Parents received a $15 gift card to a local grocery store as an incentive for completing the questionnaire.

Anthropometric measurements were collected on children. Height was measured using a free-standing stadiometer to the nearest 0.1 cm (Seca, Birmingham, UK). Waist circumference was measured using National Health and Nutrition Examination Survey (NHANES) protocol.[126] Weight and bioelectrical impedance were assessed with the Tanita Body Fat Analyzer (Tanita Corporation of America Inc, IL, USA, model TBF 300). BMI percentiles were determined using Centers for Disease Control and Prevention (CDC) age- and gender-specific values.[127]

Dietary Intake

Sixteen students (eight male and eight female) were randomly selected from each grade level at each school (for a total of 48 students/school) to be contacted for 24-h dietary recalls. If any of the 16 students were not available or did not want to participant in recalls, then additional students were randomly selected to fill in as back-ups. Each student completed two 24-h dietary recalls. Recalls were collected via telephone by trained staff and supervised by a Registered Dietitian Nutritionist using the Nutrition Data System for Research (Nutrition Coordinating Center; 2016)[128], a computer-based software application that facilitates the collection of recalls in a standardized fashion.[129] Dietary intake data gathered by interview was governed by a multiple-pass interview approach.[130] Five distinct passes provided multiple opportunities for the participant to recall food intake. Students

took approximately 20 to 30 min to complete each recall. A Food Amounts Booklet was distributed to students and used to estimate serving sizes during recalls. Menus and portion sizes were obtained from school food services to aid in collecting recalls. Parents and/or guardians of students were allowed to assist with recalls as needed. Assistance included recalling food items consumed and estimating serving sizes. Students received a $10 incentive for completing the recalls. Quality assurance was performed on all dietary recall data by additional trained research staff.

Calculation of the HEI-2015

Diet quality was assessed using the Healthy Eating Index-2015 (HEI-2015). The HEI-2015 is a valid and reliable composite measure that helps assess overall diet quality and compliance with the Dietary Guidelines for Americans-2015 (DGA-2015).[77,131] The index is appropriate for examining diet quality of the U.S. population as well as specific subgroups such as children and adolescents or racial-ethnic populations in a range of applications including epidemiology, population monitoring and surveillance, and nutrition interventions.[81] The HEI-2015 is based on thirteen components (total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, saturated fats, and added sugars).[84] The first nine components are adequacy scores, with higher scores indicating higher consumption, and scores of zero indicating no intake. The remaining four components (refined grains, sodium, saturated fat, and added sugars) are components for moderation. For moderation components, reverse scoring is applied, meaning that higher scores indicate lower consumption. Total fruit, whole fruit, total vegetables, greens and beans, total protein foods, seafood and plant proteins have a maximum score of five, and whole grains, dairy, fatty acids, refined grains, sodium, saturated fats, and added sugars which have a maximum

score of 10. A total HEI score can be derived from adding up the 13 component scores. The maximum total HEI score is 100 and signifies the highest possible compliance to the DGA-2015. HEI scores were calculated using an average of each participant's two dietary recalls. Since multiple dietary recalls were used for each participant, scores were calculated by summing across all days per participant before applying the HEI scoring standards and performing further analyses. The simple HEI scoring algorithm method[81], was used as the statistical methodology and scores were calculated using a freely available SAS code[132] developed by the University of Minnesota Nutrition Coordinating Center.

Assessment of Child Food Security

Child food security experiences were measured using a 5-item adapted version of the Child Food Security Assessment (CFSA), which was previously validated for use with children as young as six years.[17,18] One emotional subdomain item "I worry about how hard it is for parents to get enough food" included in the CFSA was removed and replaced with a child food management subdomain item "I tried not to eat a lot so that our food would last" to encompass a broader range of subdomains of child food insecurity. This item tested well in previous validation assessments.[18] All items had high sensitivity and specificity for the domain to which they corresponded to.[18] The items on the adapted CFSA represented four of six previously conceptualized subdomains of child food insecurity (Q1, emotional awareness; Q2–Q3, physical awareness; Q4, initiation of child food management strategies; Q5, cognitive awareness).[10] A reference frame of "in the last year" was used. Response categories were "a lot, sometimes, or never". Responses to the CFSA were recoded as follows: "never" = 0, "sometimes" = 1, or "a lot" = 2. Scores were summed (range 0–10) with higher scores indicative of reporting decreased food security. Scores were distributed asymmetrically with a right skew. Four ordinal groups were created that

corresponded with summed scores: 0 (high food security), 1 (marginal food security), 2 to 3 (low food security), and 4 to 10 (very low food security).[18] For analysis, these groups were collapsed to two so that summed scores of 0–1 were representative of food security and 2–10 of food insecurity.

Covariates

Covariates included in the analysis were sex, age, ethnicity/race (non-Hispanic White, Hispanic, non-Hispanic Black), Supplemental Nutrition Assistance Program (SNAP) participation (provided by the parent), average energy intake, and BMI percentile.

Statistical Analysis

Descriptive statistics (i.e., mean, standard deviation, number, percentage of sample) were used to describe the sample. Chi square (χ^2) tests and univariate linear regression models were used to determine if significant differences existed between demographic variables of food secure and insecure children. Mixed effects linear regression models were used to estimate associations between food secure and insecure groups and HEI-2015 total score, with random effects at the school level to account for clustering by schools. Interactions between food insecurity and child ethnicity/race and sex were tested. Separate mixed effects linear regression models were then used to examine associations between food security status and HEI-2015 component scores. All models were adjusted for age, sex, ethnicity/race, SNAP participation, BMI percentile, and energy intake and used robust standard errors to account for heteroscedasticity. All data were analyzed using SPSS Statistics for Macintosh, version 25.0.[133]

RESULTS

Study Sample

Of the 4239 eligible students at the 16 elementary schools, 3303 children (78%) consented to participate in the TX Sprouts study. Out of those consented children, 3137 (95%) completed baseline clinical measures and were included in the clinical trial. The analytic sample included only baseline data from the trial. A random subsample of 738 students completed two 24-h dietary recalls. After removing 26 cases with incomplete survey data for determining food security status and 73 cases with missing ethnicity/race, the sample was 639 students. Furthermore, prior to analysis, 41 cases were removed, as these participants indicated that they were of an ethnicity/race (4 Native American or American Indian; 10 Asian or Pacific Islander; and 27 Mixed or Other Ethnicity) that was too small of a percentage of the total sample to draw conclusions during analysis. These cases were not combined to form a general "other ethnicity" group because they significantly differed in demographic variables and overall diet quality. Previous research has provided evidence of an age-specific relationship between food security and dietary outcomes.[125] It has been recommended to separate samples into age subgroups (1–5 years, 6–11 years, and 12–19 years). While the current study's population age ranges from 7–13, the sample was not separated as only two participants were above the age of 11 years. The final analytic sample with complete data was 598 students.

The sample was primarily Hispanic (64%), 55% female, and had an average age of 9.2 ± 0.9 years (range 7–13 years) (**Table 9**). Food insecurity was reported by 65% of the children. A greater number of food insecure were younger and male. A greater number of Hispanic children were food insecure compared to secure; whereas a greater number of food secure children were more likely to be non-Hispanic White or non-Hispanic Black. A

significantly greater number of food insecure children reported receiving SNAP benefits compared to food secure children. Average BMI percentile for the sample was 72.5, and 49.7% of the sample were overweight or obese. There was no significant difference in BMI percentile between food secure and insecure children. There was also no significant difference in energy intake

Table 9. Characteristics of children by child-reported food-security status

Characteristics	Total Sample (n=598)	Food Secure (n=211)	Food Insecure (n=387)	*P* Value[a]
	<---- mean ± standard deviation ---->			
Age (y)	9.2± 0.9	9.4± 0.9	9.1± 0.9	<0.001
BMI Percentile	72.5± 28.2	72.4± 29.7	72.6± 28.6	0.941
Energy (kcal)	1465± 539	1450± 483	1473± 567	0.621
		<---- n (%) ---->		
Sex				0.012
Male	268 (44.8)	80 (37.9)	188 (48.6)	
Female	330 (55.2)	131 (62.1)	199 (51.4)	
Ethnicity/Race				0.001
Non-Hispanic White	139 (23.2)	66 (31.3)	73 (18.9)	
Hispanic	381 (63.7)	115 (54.5)	266 (68.7)	
Non-Hispanic Black	78 (13.0)	30 (14.2)	48 (12.4)	
SNAP Participation				0.014
Yes	179 (29.9)	50 (23.7)	129 (33.3)	
No	419 (70.1)	161 (76.3)	258 (66.7)	

Abbreviations: kcal, kilocalories; BMI, body mass index; SNAP, Supplemental Nutrition Assistance Program

[a] *p*-values are from χ^2 tests and univariate linear regression models

Associations between Food Insecurity and Overall Dietary Quality

After adjustment for sociodemographic characteristics (sex, age, ethnicity/race, and SNAP participation), BMI percentile, and energy intake, food insecurity was associated with lower diet quality scores (β = −3.17; 95% CI = −5.28, −1.06; p = 0.003) (**Table 10**).

In this full model, there was a significant association between ethnicity/race and HEI-2015 total score ($p < 0.001$). Compared to non-Hispanic Whites, Hispanic children had 4% higher HEI-2015 totals scores ($p = 0.004$). There was no significant difference between non-Hispanic Whites and Blacks. Higher energy intake was also associated with lower HEI-2015 total scores ($p = 0.011$). There was no significant interaction between food security and sex or food security and ethnicity/race; therefore, the sample was not stratified by sex or ethnicity/race for analysis. Average total HEI-2015 scores between food secure and food insecure children are shown in **Table 10**. Food secure children vs. food insecure children had higher HEI-2015 total scores (54.5 vs. 52.5; $p = 0.012$).

Associations between Food Insecurity and HEI-2015 Components

Mixed effects linear regression models were used to compare HEI-2015 component scores between food secure and food insecure children, while adjusting for sociodemographic characteristics, BMI percentile, and energy intake (**Table 11**). Compared to food secure children, food insecure children had lower component scores for greens and beans (2.32 vs. 1.86, $p = 0.016$), lower mean seafood and plant protein (2.04 vs. 1.62, $p = 0.006$), and lower added sugar (7.95 vs. 7.39, $p = 0.002$). Of note, added sugar is a moderation HEI-2015 component (reverse scoring is applied during calculation of the component score), meaning that a higher component score is representative of lower mean consumption. Figure 1 depicts a radar plot that was constructed to provide a visual representation of the differences of how food secure and food insecure children obtained their overall HEI-2015 scores. Component scores were graphed as percentages (e.g., a total fruit score of 4 out of 5 was graphed as 80%). A perfect HEI-2015 score (100% for each component) would be displayed as a line around the exterior border of the radar plot.

Table 10. Mixed effects linear regression model of food security status and Healthy Eating Index-2015

	Unstandardized β	Standard Error	95% Confidence Interval for β	*p*-Value
Age	-0.05	0.05	-0.15, 0.06	0.362
Sex				0.200
Male	Referent	---	---	----
Female	-2.52	1.69	-5.84, 0.78	0.134
Ethnicity/Race				<0.001
Non-Hispanic White	Referent	---	---	----
Hispanic	3.79	1.29	1.22, 6.30	0.004
Non-Hispanic Black	-0.347	2.89	-4.89, 4.14	0.879
Energy (kcal)	-0.003	0.001	-0.006, -0.001	0.011
SNAP Participation (yes)				0.200
Yes	Referent	---	---	----
No	1.6	1.25	-0.85, 4.05	0.200
BMI Percentile	-0.03	0.001	-0.06, 0.01	0.105
Child-Level Food Security				0.005
Food Secure	Referent	---	---	----
Food Insecure	-3.17	1.08	-5.28, -1.06	0.003
Food Security x Sex Interaction				0.194
Male	Referent	---	---	----
Female	2.05	1.60	-1.08, 5.19	0.126
Food Security x Ethnicity Interaction				0.287
Non-Hispanic White	Referent	---	---	----
Hispanic	-3.19	2.52	-8.13, 1.75	0.205
Non-Hispanic Black	-4.37	2.78	-9.83, 1.09	0.116

Abbreviations: kcal, kilocalories; SNAP, Supplemental Nutrition Assistance Program; BMI, Body Mass Index

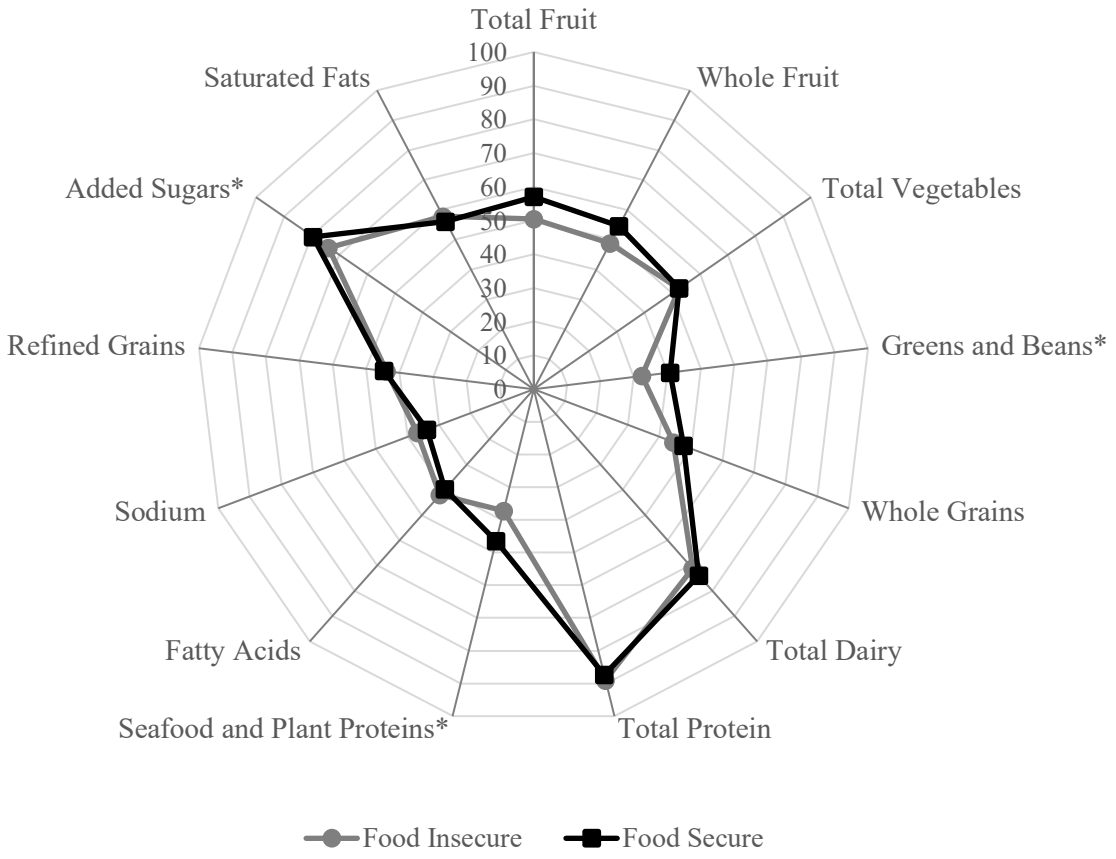

Figure 4. Radar plot visualization of average Healthy Eating Index-2015 component scores contributing to the total score in food insecure and food secure children. Significant differences (p<0.05) in mean component scores between food insecure and food secure children are denoted with an asterisk

Table 11. Mixed effects linear regression model of food security status and Healthy Eating Index-2015 and component scores[a]

Parameter	Unstandardized β	Standard Error	95% Confidence Interval for β	Means		*p*-Value
				Food Secure	Food Insecure	
HEI Total Score	-1.98	0.79	-3.52, -0.43	54.48	52.50	0.012
Total Vegetables	-0.01	0.14	-0.28, 0.26	2.63	2.62	0.940
Greens and Beans	-0.42	0.15	-0.72, -0.12	2.04	1.62	0.006
Total Fruit	-0.33	0.17	-0.67, 0.01	2.85	2.52	0.059
Whole Fruit	-0.29	0.19	-0.67, 0.09	2.73	2.44	0.132
Whole Grains	-0.32	0.27	-0.89, 0.20	4.76	4.44	0.223
Total Dairy	-0.27	0.30	-0.86, 0.32	7.39	7.12	0.363
Total Protein	0.09	0.10	-0.10, 0.27	4.37	4.45	0.378
Seafood and Plant Protein	-0.46	0.19	-0.84, -0.09	2.32	1.86	0.016
Fatty Acids	0.20	0.34	-0.46, 0.87	3.98	4.19	0.546
Sodium	0.29	0.17	-0.05, 0.63	3.39	3.68	0.095
Refined Grains	-0.08	0.32	-0.71, 0.55	4.47	4.39	0.802
Added Sugar	-0.56	0.18	-0.92, -0.21	7.95	7.39	0.002
Saturated Fat	0.17	0.27	-0.35, 0.69	5.62	5.79	0.521

[a] Food secure was the referent group. Models controlled for sex, age, ethnicity/race (non-Hispanic White, Hispanic, non-Hispanic Black), Supplemental Nutrition Assistance Program (SNAP) participation, average energy intake, and BMI percentile.

DISCUSSION

Diet quality, as measured by the HEI-2015, was lower in food insecure children compared to food secure children. This is the first study to show a relationship between dietary quality and food insecurity while using a child's own report of their food security experiences. Overall, diet quality for all children was low, but similar to those found in a nationally representative sample of U.S. children (6–11 years).[134] Previous research has reported that dietary quality differs by ethnicity/race in nationally representative child samples.[134-136] This study found that diet quality did not differ by sex but did significantly differ by race/ethnicity. Contrary to our hypothesis; however, the interaction between food insecurity and ethnicity/race was not significant.

Previous research in studies of children and adolescents have found no association between food insecurity and dietary quality.[17,88,89] Differences from previous studies of children may be attributed to using child report or controlling for a different set of confounding variables that may affect this relationship.[137] Other possible explanations for the novel differences found in this study include whether or not participants utilized food assistance programs. Participation rates in the SNAP by food insecure and food secure children differed within our sample; however, research has found that children's diets were similar among SNAP participants and low-income nonparticipants. Furthermore, this study only asked about current SNAP participation, reductions or loss of benefits over time may impact dietary intake and may be associated with greater odds of food insecurity.[138] While not measured in this study, food-insecure households are much more likely to use a food pantry or food bank than food-secure households and the nutrient quality of foods obtained at local food banks or food pantries can vary.[139,140] The results of this study were consistent

with those in nationally representative samples of adults, which have found that food insecurity is associated with lower dietary quality.[141,142]

While similar recent studies[88,89] have focused on differences in total HEI score in food secure and insecure children, this study also sought to examine component scores of the HEI-2015 to maximize understanding of dietary quality of patterns of food intake. HEI components can be considered as a set of scores, each measuring alignment with a different aspect of the DGAs and serve as targets for improvements in nutrient density within the diet. Food secure compared to food insecure children had greater intakes of greens and beans, and seafood and plant proteins, and lower intake of added sugar.

The associations between the greens and beans component and the seafood and plant proteins component and food insecurity found in this study has not been previously reported by others. This may be in part due to the fact that other studies have utilized previous versions of the HEI and as a result may not be directly comparable.[81] For example, in HEI-2015, legumes were allocated to both protein and vegetable components.[84] Therefore, HEI-2015 component scores for total vegetables, greens and beans, and seafood and plant proteins may have been higher than component scores for HEI-2010. Furthermore, much of the existing literature has reported on vegetable intake in general and have found no association with food security status and specific types of vegetable intake.[78] Fram et al. 2015, however, reported that food insecurity was associated with a lower HEI-2005 total vegetable component score in a sample of 9 to 11 year old children.[9] Further research is needed to clarify the relationship between food insecurity and vegetable intake, including type of vegetables, as well as the potential barriers that food insecure households face in access, availability, and utilization of vegetables.

This study also found a significant association between the added sugar component and food insecurity. Food insecure children had higher intakes of added sugar compared to

food secure children. Most previous studies have reported on added sugar intake separately from the HEI. Sharkey et al. found that food insecurity was associated with higher added sugar intake in a convenience sample of Texas children (6–11 years of age).[143] Fram et al. found that food insecure children compared to food secure children consumed eight grams more of added sugar per day.[17] However, research has also found no association[88] and even an inverse association[144] between food insecurity and added sugar intake in children. Additional research is needed to determine if added sugar intake differs between food insecure and secure children.

There is evidence suggesting that dietary habits and patterns established during childhood may persist into adulthood.[145] Experiencing food insecurity during critical points in a child's development may put them at increased risk of chronic diseases. Diets of children within this study, particularly those who were food insecure, strayed from current national dietary recommendations.[77] Early modification of these dietary behaviors in children who are food insecure may promote health and decrease risk of developing chronic diseases over a lifetime.[76,146] Interventions that alleviate the burdens of food insecurity and target improvements in diet quality are needed.

Limitations and Strengths

This was a cross-sectional analysis; therefore, no causal relationships could be inferred. However, this analysis used baseline data from an intervention trial, so changes in food security in relation to changes in diet quality can be examined at a later date. Another limitation is that food insecurity is episodic in nature and may be perceived by children differently throughout the year or even month, leading to potential misclassification of food security status. Due to the small sample size and distribution of individuals within food security groupings, this study collapsed the traditional four

categories of food security (high, marginal, low, very low) down to food secure (encompassing high and marginal) and food insecure (encompassing low and very low). Self-reported dietary intake is subject to measurement error, bias, and social desirability.[147-150] In addition, dietary assessment in children poses unique challenges including a potentially limited concept of time, food recognition and knowledge of preparation methods, ability to quantify estimated portion sizes, motivation, literacy, memory capabilities, and concentration span.[151-153] However, when measurement error is taken into consideration during interpretation of data, self-report data remain useful and valuable.[154]

The use of self-report of child food insecurity experiences is seen as a strength of this study. Child-report of their personal experiences with food insecurity has been shown in the literature to be more representative of their actual experiences and rules out potential biases that may result from parental reporting.[18-20,23,94] Sample size for this study was smaller than previous studies and is only locally representative; however, the scale of this study enabled us to control for confounding variables of potential relevance to food insecurity and diet, such as body weight or BMI, which prior studies have not controlled for.

CONCLUSIONS

Poor dietary quality was observed in a low-income, multiethnic sample of 7 to 13 year old children. Significant differences in HEI component scores were observed between food secure and insecure children. Food insecure children had lower overall diet quality and had lower scores for greens and beans, seafood and plant proteins, and added sugar HEI-2015 components. This study contributes to our understanding that dietary intake of food insecure children differs from low-income, food secure children; however, further research is needed to explain why these differences exist. Additional research is needed in

large, nationally representative samples where food security status is self-reported by children to better understand the complex interplay between food insecurity and dietary intake. Interventions targeting low-income and food insecure children should investigate methods to improve dietary quality.

CHAPTER 5: CONCLUSIONS AND PUBLIC HEALTH IMPLICATIONS

The US Department of Health and Human Service's Healthy People 2020 national objectives for improving the health include two objectives focused on food insecurity: 1) Eliminate very low food security among children (NWS-12); and 2) Reduce household food insecurity and in doing so reduce hunger (NWS-13).[155] The findings gleamed from this research help contribute towards achieving those objectives. The purpose of this research was to examine associations between dietary quality, vegetable availability and access, and food insecurity within low-income children. More specifically, this research addressed: 1) examining differences in perceptions of child-level food insecurity using the 8-item child-referenced USDA HFSSM completed by parents compared to an adaption of the 5-item CFSA completed by children; 2) examining the relationship between individual and interpersonal barriers to availability, access and utilization of vegetables and household food insecurity; and 3) examining the relationship between self-reported food insecurity and dietary quality in children. All three aims were analyzed using data from TX Sprouts, a cluster-randomized school-based gardening, cooking, and nutrition intervention. TX Sprouts targeted 3rd-5th grade students and their parents from 16 elementary schools in the Greater Austin area. Students were primarily Hispanic and low-income, which is a population disproportionally impacted by food insecurity and chronic diseases.[1,97,98]

There is a need to directly and accurately conceptualize and measure food insecurity in children as part of surveillance and monitoring efforts. Further, with looming cuts to appropriations for federal food assistance program, research is needed to understand the true prevalence and impact that food insecurity has on health parameters, providing evidence for the necessity of these programs. This study found that child and parent

perceptions of child-level food security were not in agreement and children perceived more food insecure experiences. The results of this research, in combination with the existing literature, suggest that parent perceptions of child-level food insecurity may underestimate child-level food insecurity experiences.

National surveys such as NHANES, NHIS, or ECLS should still utilize parental report of household food insecurity. However, with the knowledge that child experiences do not always mirror those of the household, national surveys should also consider collecting food insecurity data using child report. This addition would provide for a greater understanding of how to strengthen public health programs and nutrition assistance programs to better serve and protect children from food insecurity. Child report should also be used in research settings when examining the impact of food insecurity on health, education, behavioral, or any other outcome related to child development.

Physicians – especially pediatricians – and other healthcare providers such as Registered Dietitians (RDs) play a vital role in screening patients and clients for food insecurity. These healthcare providers also play an essential role in advocating for programs and policies that work towards ending child food insecurity. In 2015, the American Academy of Pediatrics published a policy paper with recommendations that pediatricians screen for food insecurity at wellness visits, familiarize themselves with community resources to refer families to, and be aware of the factors that may increase vulnerability to food insecurity.[156] Similarly, the Academy of Nutrition and Dietetics (AND) released a position statement discussing the contributions RDNs can make towards alleviating food insecurity through community-based education, practice, research, advocacy, and policy.[124]

Pediatricians and RDs should be further educated to ask not only parents about the home food environment and potential risk of food insecurity but also ask children about

their individual experiences. Further research may be needed on best practices for implementation of this within a clinical setting. These practitioners should understand that food insecurity may impact children differently than their parents and may need access to different or additional community resources and programs from their parents.

While previous studies have typically examined the food system domains[2] of availability, access, and utilization of vegetables within low-income households independently, this study examined all three within our low-income population. This study found that decreased availability of fresh vegetables and increased barriers to access (vegetables being too expensive and being unable to find quality vegetables) and utilization (hard to use before spoilage, no time for preparation, not knowing simple, easy recipes, and family not helping with cooking) were associated with greater odds of being food insecure. This research has direct implications on public health as the barriers to availability, access, and utilization of vegetables that were associated with household food insecurity can be used to guide and influence the development of future interventions and public policy aimed at improving child health.

Out of the three food system domains assessed the utilization domain is the most understudied and reported on in the literature. Utilization incorporates all household practices and individual behaviors in the transformation of food into meals including planning, management, selection of foods, preparation and cooking skills and these barriers encompass aspects that are tied to food literacy (practical food knowledge and skills).[2,24,49] Further research can focus on why food insecure individuals face lack food literacy such as decreased attitudes or self-efficacy towards cooking. Additionally, out of the three food system domains, utilization barriers can be most readily and easily addressed through targeted, multi-context or multi-level public health interventions and nutrition education.

There is evidence that suggests that dietary habits and patterns established during childhood may persist into adulthood.[145] Experiencing food insecurity during critical points in a child's development may put them at increased risk for chronic diseases. This research found that dietary quality was inversely associated with food security in a multi-ethnic sample of 7-13-year-old children. Although diets of most children in the US are poor[135], this study found that food insecurity was associated with even lower overall diet quality. Additional research into how food insecurity impacts diet and subsequent health risk is needed in large, nationally representative samples where food security status is self-reported by the children. While significant adverse associations between food insecurity and health outcomes have been well established[90] the use of child report may reveal the true extent of detrimental effects on child health and development. With the current evidence, public health programs and interventions should be developed that target improving dietary quality of low-income and food insecure populations. Early modification of poor dietary behaviors in children who are food insecure may promote health and decrease risk of developing chronic diseases over a lifetime.[76,146]

CHAPTER 6: FUTURE PLANS AND AVENUES OF RESEARCH

Starting in the Fall of 2019, I will begin the Coordinated Program in Dietetics (CPD) at The University of Texas at Austin (UT-Austin). After completing the UT-Austin CPD, I would like to return to academia. I hope to compete for a prestigious post-doctoral fellowship with a nutrition or public health focus. I would like to pursue a postdoctoral position that would build upon my current experience in behavioral and public health nutrition while additionally obtaining skills in areas such as program evaluation, epidemiology, longitudinal study design and data analysis, use of national survey data (such as NHANES or NHIS), and dietary feeding studies. Ultimately, I would like to apply for a tenure-track position at a research-intensive university where I would have the opportunity to continue my research, teach undergraduate and graduate level courses, provide leadership and service on the university and national level, and mentor students.

Over the past four years, I've been grateful to work on TX Sprouts, a cluster-randomized school-based gardening, cooking, and nutrition intervention. I was lucky to join the project at its early stages and contributed to developing curricula used in the elementary school lessons, organizing survey items used in our questionnaires for data collection, and establishing connections with key external stakeholders. Over the course of the project, I was able to learn how to overcome and adapt to challenges that arose. My most substantial contribution on the project was managing the collection of over 2,500 24-hour dietary recalls. In 2017, I went to Nutrition Coordinating Center at the University of Minnesota for an intensive 3-day training to become certified as a Nutrition Data Systems for Research (NDS-R) Dietary Interviewer. Over the past three years, I trained, re-trained and supervised over 90 undergraduate students to collect the 24-hour recalls. Being involved with this aspect of the project helped fuel my interest in dietary assessment.

I have a passion for understanding the impact that dietary patterns, established during childhood, have on the risk of obesity and chronic diseases and how effective community design, steady healthcare systems, innovative public health programs, and thorough public policy strategies can reduce those risks. I am ultimately interested in what people are eating, why they're eating those foods, and how we can make dietary intake better. It is my ultimate goal to decrease chronic disease risk factors in populations that are disproportionally impacted by health disparities.

The valued experiences throughout my doctoral education have allowed me to creatively see gaps within nutrition and public health fields. These gaps serve as both targets for further research to understand the critical role of nutrition in health and chronic disease prevention, as well as targets for future behavior nutrition interventions. In my future research, I hope to take a life course approach through targeted interventions focusing from expecting families to elementary aged children, to geriatric populations. Below I have outlined potential areas of research that I would like to investigate.

As the world population continues to grow older, there is an increased need for interventions that target the unique needs of this population. As a research assistant for the TX Sprouts project, I saw first-hand the tangible benefits of gardening, cooking and nutrition in elementary aged children. I think this idea could be adapted for a geriatric population and its effects could be tested through a randomized control trial within assisted living communities. In addition to the potential improvements in dietary quality and metabolic health, I believe exposure to gardening would be most beneficial to a geriatric population though improvements in psychological behaviors and mental stimulation.

There has been an abundance of research into the factors that promote health and well-being of expecting, pregnant, and new mothers; however, there is a dearth of research that looks into paternal health during this significant life event. I am interested in

investigating changes in diet quality, metabolic risk factors, and adiposity in expecting and new fathers. Further research in this area can compare changes between differing racial/ethnic or socioeconomic groups. Insights from this research could help direct future public health efforts that support health and wellness of the growing new family.

Having collected thousands of dietary recalls, I have realized that the diets of children, particularly low-income children, could be greatly improved. I would be interested in determining how seasonality of foods, particularly fresh vegetables and fruits, may impact diet quality. I am also interested in understanding how diet quality changes from the school year, when much of a child's dietary intake is provided within the school environment, to the summer months where dietary intake comes from a greater variety of sources. Previous longitudinal research has reported that children maintain weight during the school year and gain weight during the summer months when they are out of school.[157,158] This gain in adiposity disproportionally affects children from ethnic/racial minorities. The mechanism for this increase in adiposity is still unclear.[159,160] The skills that I gained during my doctoral program would allow me to determine if this weight gain is a result of changes in diet quality, physical activity, or a combination of the two. Lastly, I would be interested in studying how food insecurity changes throughout the year in children and how these potential changes impact dietary intake. Much of the current research in this area has utilized only cross-sectional data; however, food insecurity is largely episodic in nature. Longitudinal data would all for a better representation of the episodic nature of food insecurity on diet quality.[2,3]

Lastly, the use of meal kits, subscription-based foodservice business models where a company sends consumers pre-portioned and sometimes partially-prepared food ingredients and recipes to prepare home cooked meals, are growing in popularity.[161] There is evidence to suggest that cooking at home is associated with better diet quality.[162]

However, there is a lack of research on the topic including reasons for consumers subscribing, if meal kits can improve attitudes and self-efficacy towards cooking, do meal kits improve overall dietary quality, are meal kits companies more or less sustainable compared to traditional meal preparation, and are consumers aware of potential food safety concerns from meal kits.

The research that I completed during my dissertation has given me a strong understanding of nutrition-related health inequalities. In all of my future research, I am committed to exploring and understand how food insecurity is associated with adverse health and wellbeing. Considering the social determinates of health and how these factors contribute to diet-related diseases, I am interested in further exploring policies that provide equitable access and availability to nutritious foods that are encouraged in our federal nutrition guidelines. I look forward to applying my solid foundation as a behavioral nutritionist to building a successful research career that has meaningful impacts on the health and well-being of individuals.

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