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UNIVERSITY OF CALIFORNIA,
IRVINE

# The Relationship Between Food Insecurity and Type II Diabetes Among Latinos

DISSERTATION

submitted in partial satisfaction of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in Public Health

by

Brandon Osborn

Dissertation Committee:
Associate Professor Annie Ro, Chair
Associate Professor Andrew Odegaard
Assistant Professor Brittany Morey

2022

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# DEDICATION

To my mother,

thank you for your support and unconditional love. I would not be the man I am today without the sacrifices you have made and the resilience you have instilled in me.

To Sarah,

thank you for pushing me to be better in every way possible. Your continued support has allowed me to reach my goals. You are my rock.

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# ACKNOWLEDGEMENTS

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Without the mentorship, investment, and support of many others, this dissertation as well as my academic career would not exist.

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Torres S, **Osborn B**, Hueston W. Midwestern medical students crave nutrition education. Poster presentation, American College of Lifestyle Medicine Annual Conference, October 2020.

**Osborn B**, Ro, A. Food insecurity and type 2 diabetes among Latinos: Examining neighborhood cohesion as a protective factor. Poster presentation, Interdisciplinary Association for Population Health Sciences (IAPHS) Annual Meeting, October 2020.

**Osborn B**, Albrecht S, Fleischer N, Ro, A. Food Insecurity, Diabetes, and Diabetes Management among Latinos: Differences by Nativity and Duration of Residence. Poster presentation, Interdisciplinary Association for Population Health Sciences (IAPHS) Annual Meeting, Seattle WA, October 2019.

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# ABSTRACT OF THE DISSERTATION

The Relationship Between Food Insecurity and Type II Diabetes Among Latinos
By
Brandon Osborn
Doctor of Philosophy in Public Health
University of California, Irvine, 2022
Associate Professor Annie Ro, Chair

*Background:* Latinos are disproportionally affected by both food insecurity and type II diabetes (T2D). Additionally, the relationship between food insecurity and T2D is more robust among Latinos compared to other racial/ethnic groups, underscoring the importance of examining this relationship in depth among this population. In this dissertation, I begin with a review of the literature and present a conceptual framework. I then examine three major aspects of the relationship between food insecurity and T2D among Latino adults by first identifying who is most at-risk for T2D when food insecure, second understanding the relationship between food insecurity and diet, and lastly, testing whether a community-level resource buffers this relationship. *Methods*: In Chapter Two, I determine which food-insecure Latinos are most at risk of having T2D. I use logistic regression to examine the association between food security status and T2D, and test whether nativity status and duration of residence moderate this association. In Chapter Three, I use exploratory factor analysis to derive dietary profiles among Latino adults and examine the association between food security status and these dietary profiles using OLS regression. In Chapter Four, I use logistic regression to test whether neighborhood social cohesion moderates the relationship between food security status and T2D. *Results*: I find that food security status is associated with T2D such that Latinos with higher levels of food insecurity are more likely to report having T2D, but this relationship differs among Latinos

of different nativity and duration of residence in the United States. Latinos born in the United States and longer stay immigrant Latinos (10 years or more in the US) have a higher likelihood of having T2D when food insecure compared to recent immigrant Latinos (less than 10 years in the US). I also find that food security status is associated with some specific dietary profiles among Latinos adults. Compared to food-secure Latinos, those who are food insecure are more likely to have consumed diets high in vegetables and plant-based foods, but not more likely to have consumed diets high in high in hyperpalatable foods such as solid fats, cheese, and refined carbohydrates. Lastly, I find that neighborhood social cohesion does not modify or buffer the association between food security status and T2D. *Conclusion*: The findings from this dissertation have important implications for the overall health of Latinos and inform future research as well as interventions. One, this dissertation contributes to the literature by identifying the most at-risk Latinos (by nativity status and duration of residence) of the relationship between food security status and T2D. Two, this dissertation identifies nuances in dietary intake by different levels of food security among Latinos by highlighting that food insecurity is not associated with the consumption of poor dietary patterns, but is associated with decreased consumption of high-quality dietary patterns. Lastly, other psychosocial factors besides neighborhood social cohesion should be empirically tested to see how these factors might reduce food insecurity's adverse impact among Latinos. Future research should examine more upstream factors such as policy to improve food environments and access to fresh and nutritious foods.

# CHAPTER 1
# Introduction: Food Security Status and Type II Diabetes Among Latinos

In the United States, there were approximately 37.1 million adults with diabetes in 2019, which was 14.7% of all adults in the country.[1] An estimated 28.5 million adults—or 8.7% of the U.S. population had been *diagnosed* with diabetes by 2019, which leaves approximately one in four adults in the US unaware that they have diabetes.[1] Type II diabetes (T2D) accounts for 90-95% of these estimates among adults.[2] In 2019, T2D was the 7th leading cause of death in the United States.[3] The prevalence and burden of T2D also differs by race and ethnicity. For example, among adults aged 18 and older, Hispanics had a higher prevalence of diagnosed diabetes (12.5%) compared to non-Hispanic whites (7.5%), non-Hispanic Blacks (11.7%), and non-Hispanic Asians (9.0%) during 2017-2018.[1] In 2019, T2D was the 5$^{th}$ leading cause of death among Latinos and Hispanics.[3] Certain Latino subgroups are disproportionally affected by diabetes, with a higher prevalence of undiagnosed and diagnosed diabetes among Mexicans (14.4%) and Puerto Rican (12.4%) subgroups compared to non-Hispanic whites (7.5%).[1]

The prevalence of diabetes in the United States has continued to increase over the last 35 years and has more than doubled.[1] As the prevalence of diabetes in the United States increases, so does the public health burden. Diabetes is a chronic disease that affects the physiological process of converting food into energy.[4,5] When food is digested, it is converted to glucose and released throughout the body's bloodstream. In response to blood glucose levels rising, the pancreas produces a hormone called insulin. Insulin allows glucose to enter cells throughout the body for use as energy. Individuals with T2D

metabolize carbohydrates abnormally and thus levels of blood glucose are elevated in the blood and urine, resulting in hyperglycemia.[4,5] This process can have profound negative effects on the body and can cause serious health complications such as chronic kidney disease, kidney failure, vision loss and hearing impairment, increased cardiovascular disease risk, and neuropathy.[5]

*Social Determinants of Type II Diabetes*

Traditional risk factors for T2D are genetic and behavioral (lifestyle) factors that increase insulin resistance. Increased adiposity, or being overweight or obese, leads to insulin resistance as a build-up of adipose deposits surrounding the cell prevents the reception of insulin.[6] The main culprit of increased adiposity is excess energy, or lack of energy balance, as being in a caloric surplus leads to weight gain. The existing literature has identified many social and environmental factors that are associated with insulin resistance and increased risk for diabetes.[7,8] In the United States and abroad, income, education, housing and the built environment, access to affordable and quality care, and access to nutritious foods are highly influential to the onset and progression of T2D. At the individual level, socioeconomic status (SES), consisting of income, education, and occupation, has a graded association with diabetes prevalence.[8–10] The lower a person's SES, the more likely they are to develop T2D or to experience diabetes-related complications. The higher a person's SES, the less likely they are to develop T2D.[8–10] Individuals with lower income and less education are two to four times more likely to develop diabetes compared to their higher-income and more educated counterparts.[7] At the environmental and neighborhood level, the built environment is also a social

determinant of T2D. The walkability of neighborhoods and access to greenspace have been consistently associated with lowered risk of having T2D.[8,11,12] Social context also determines T2D risk. Several psychosocial factors such as social capital, social cohesion, and social support are positively associated with diabetes prevention and control.[8] Social capital is associated with the management of diabetes.[13] In addition, higher levels of social cohesion are associated with a lower incidence of T2D.[14]At the policy level, accessibility and affordability of quality health care are also social determinants of health. For example, after the passage of the 2010 Affordable Care Act, in states that expanded Medicaid, Medicaid patients with diabetes were diagnosed and treated earlier than patients living in states that did not expand Medicaid.[15] Overall, uninsured adults in the United States have a higher likelihood of having undiagnosed diabetes compared to insured adults.[16]

Among other social determinants, *food insecurity* has been found to be a significant risk factor for developing diabetes.[17] The United States Department of Agriculture defines food security as access by all people at all times to enough food for an active, healthy life.[18] Approximately 13.8 million (10.5%) of households in the United States were food insecure in 2020 with 38.3 million people living in these households.[19] There is clear social patterning of food insecurity by race and household size. In 2020, 21.7% of non-Hispanic Black households and 17.2% of Hispanic households were food insecure, higher than the national average of 10.5% and the average of 7.1% among non-Hispanic White households.[19] During the 2008 economic recession, Latinos experienced the highest increase in food insecurity compared to any other racial or ethnic group (20% in 2007 versus 27% in 2008) which highlights Latinos' particular sensitivity to food

insecurity during economic downturns. Household composition is also a determinant of food insecurity. In 2020, Households with children less than 18 years of age were more likely to be food insecure (14.8%) than households without children less than 18 years of age (8.8%). Among households with children, 27.7% of households headed by a single woman were food insecure in 2020.[19]

The relationship between food insecurity and T2D has been consistently established throughout the literature.[20–24] This is especially evident by the higher prevalence of diabetes in households that are food-insecure compared to food-secure households. One study showed a 3% difference in diabetes prevalence among adults between food-insecure households (10.2%) and food-secure households (7.4%) in the United States.[25] When observing the intersection of food insecurity and T2D, another study found that adults living in food-insecure households have a 50% higher risk of developing diabetes compared to adults among adults living in food-secure households.[25] In addition, food-insecure adults have been found to be two to three times more likely to have diabetes compared to their food-secure counterparts, even after adjusting for other risk factors such as lifestyle factors, income, employment, and physical measures.[22,23]

While food insecurity can be caused by having low income, food insecurity is a distinct determinant of T2D from poverty.[26] In fact, close to half of all families reporting food insecurity have incomes above the official poverty line.[27–29] Food insecurity is also influenced by the local food environment and accessibility to nutritious foods. Access to nutritious food can be a challenge, specifically in rural areas and inner cities where the availability of grocery stores and places to purchase healthy foods is limited[30,31] These

factors make food insecurity a unique type of stressor and determinant of T2D, independent of poverty.

*Food Insecurity and Type II Diabetes among Latinas/os*

The relationship between food insecurity and T2D differs by specific populations. Additionally, the mechanisms between food insecurity and diabetes are not yet fully understood due to these differences in populations as well as inconsistency in the methodologies and measurement examining this relationship.[21] Age, sex, and race differences in the association between food insecurity and T2D have been presented throughout the literature. In the majority of empirical literature among US adults, women, particularly Latinas, and older adults may be most likely to have T2D when food-insecure.[20,23,32–34] Among older adults, food insecurity is associated with T2D.[34] One longitudinal study found that homebound older adults with T2D (N=268) are twice as likely to be food-insecure than older adults without T2D.[35] Additionally, among older adults with food insecurity, some racial/ethnic groups seem to be especially at risk for T2D. For example, a study among older adults found that compared to food-insecure Non-Hispanic Whites, food-insecure Mexican-Americans, Non-Hispanic Blacks, and Non-Hispanic Asians had a higher odds of T2D, with Mexican-Americans and Non-Hispanic Asians having over two times the odds of T2D.[36]

The relationship between food insecurity and diabetes among the general adult population in the United States is also moderated by sex; the risk that food insecurity poses for T2D seems to be especially salient for women compared to men.[23,32,36] This pattern

exists among older adults as well, with older women being more likely to have T2D when food-insecure compared to their male counterparts.[34] Women's contributions towards meal preparations, their role in society as child bearers and caregivers, the increase in female-headed households, and the income wage gap between women and men should all be considered when discussing the disproportion negative health outcomes among food-insecure women.[37] There is also a gendered expectation that mothers are responsible for feeding their children.[38,39] This is evident by the fact that mothers are more likely to skip meals compared to fathers so their children have sufficient food and nutrition, which increases their risk for stress, obesity, depression, and T2D.[38,39] Additionally, food-insecure mothers are more likely than food-insecure fathers and child-free women and men to be overweight or obese.[37] The effect modification by sex does not hold when samples are stratified by race/ethnicity groups, however, suggesting that not all women are particularly more vulnerable than men. For example, in some racial/ethnic groups, the pattern is opposite from national trends. A study among a state-representative sample of adults in California found that non-Hispanic white men are more likely to have T2D when reporting low food security compared to non-Hispanic white females.[40]

Latinas seem to have a particularly high odds of having T2D when food insecure. Fitzgerald et al. found that Latinas with very low food security were 3.3 times more likely to have T2D.[23] When examining both race and sex differences simultaneously, Latinas were the only racial/ethnic group to have a significantly high risk of T2D at all levels of food insecurity, low food security and very low food security compared to food security.[40] This contrasts with other groups where there is a significant association only between certain

levels of food insecurity T2D. For example, among non-Hispanic white women, having very low food security (compared to food security) is positively associated with T2D, but not low food security. Among non-Hispanic white men, having low food security (compared to food security) is positively associated with T2D, but not very low food security.[40]

Food insecurity also appears to raise the risk for poor outcomes among Latinos with T2D as well. One study among Spanish-speaking Latinos with T2D found that food insecurity is associated with greater autonomic nervous system dysfunction, a condition that increases diabetes-related mortality.[41] Overall, the link between food insecurity and T2D is robust among Latinas/os compared to other racial/ethnic groups, underscoring the importance of examining this association in depth.[18,22,23]

Just as there are social factors that modify the relationship between food insecurity and T2D in the general population, there may be segments of the Latino population that are more at-risk of T2D when food insecure. Latinos of different nativity and duration of living in the United States may be particularly more at-risk of T2D when food insecure. For food-insecure Latinos, other chronic diseases, such as obesity, differ by nativity and duration of living.[42] Nativity and duration are important demographic factors to consider because health behaviors and outcomes shift as Latino immigrants live longer in the United States.[43,44]

Further, the mechanisms between food insecurity and T2D are not yet fully understood.[21] Justification behind *why* food-insecure Latinos are more likely to have diabetes compared to other food-insecure populations has not been studied. In addition,

the research on mechanisms and pathways between food insecurity and T2D among adults is sparse but has increased in recent years with mediators such as stress, diet, and obesity being presented in the literature.[20]

The lack of this foundational information (in both differential risk and mechanisms) poses a critical barrier to identifying solutions that prevent and reduce T2D among Latinos of different food security statuses. In the absence of such knowledge, addressing prevention and treatment will likely remain difficult. Increased T2D prevalence among Latinos is a likely consequence of a failure to identify those most at-risk, understanding the potential pathways between food insecurity and T2D, and identifying possible solutions that may buffer the association between food insecurity and T2D among them. This dissertation adds to the body of literature to address these gaps in knowledge by further exploring this relationship among Latinos.

## THE PRESENT STUDY

In this dissertation, I focus on exploring three major aspects of the relationship between food insecurity and T2D among Latinos. First, I identify among Latinos, who are the most at-risk of having T2D when food insecure. I specifically examine nativity and duration of residence among Latinos in the United States. I also examine the association between food security status and self-management of T2D and whether it is moderated by nativity/duration. Second, I use data-driven exploratory methods to examine the relationship between food security status and dietary intake among a national sample of Latinos using an *a posteriori* approach. Through this approach, I identify which dietary patterns, or profiles, are most common among Latinos across the United States and

whether people with differing food security statuses have unique dietary profiles. Lastly, I examine whether a neighborhood social cohesion acts as a community-level resource and buffers the association between food insecurity and T2D among Latinos. These contributions are significant because they fill an important gap in the literature, generate valuable knowledge, and will provide justification for the development of tailored interventions which ultimately will decrease disparities in T2D-related morbidity, mortality, costs, and improve the overall quality of life among Latinos. By identifying the most at-risk Latinos, empirically examining the relationship between food insecurity and dietary intake using robust dietary measurements, and examining whether neighborhood social cohesion buffers food insecurity's adverse impact on T2D incidence, this research establishes which Latinos would benefit most from targeted interventions and influence how interventions are best designed for this population.

## CONCEPTUAL FRAMEWORK

My conceptual model is presented in Figure 1.1. The centerpiece of the model is the relationship between household food insecurity and cardiometabolic health outcomes, including T2D. This conceptual model is influenced primarily by the *Social-Ecological Model of Health*.[45,46]In particular, *intrapersonal* or individual-level factors, *interpersonal and community*-level factors, and *policy*-level factors contribute to specific aspects of the relationship between food insecurity and cardiometabolic health outcomes. On the left-hand side and bottom of my conceptual model, I present antecedents of food insecurity such as sex, income, household size, segregation, and the food environment. The

conceptual model identifies two pathways linking household food insecurity status and cardiometabolic health outcomes: chronic stress and dietary intake. There are also two moderators: neighborhood social cohesion and nativity/duration in the United States.

In this section, I present a review of the literature that contextualizes my conceptual framework. First, I focus on antecedents of food insecurity. Then I discuss the disparate relationships between food security status and T2D among Latinos of different immigration statuses. Then I present the state of the science regarding the relationship between food security status and dietary intake with a particular focus on measurement. Lastly, I review the literature around neighborhood social cohesion and its potential to be an important resource for Latinos experiencing food insecurity that may help buffer its effect on T2D incidence.

*Individual and Household-Level Antecedents of Food Insecurity*

*Intrapersonal* or individual-level factors such as education, income, employment, and access to public benefits, specifically the Supplemental Nutrition Assistance Program (SNAP), are all determinants of food insecurity.[47] Employment, education, and income have an inverse relationship with food insecurity, whereas higher levels of education and/or income and full-time employment are associated with food security and lower levels are associated with food insecurity.[47] SNAP prevents and reduces the level of food insecurity, specifically in low-income homes with children.[48] Additionally, household-level factors such as household size and family-make-up (marital status, with or without children, etc.) also are determinants of food insecurity. Household size is proportionally related to food insecurity, on average when the number of persons living in a home increases, so does the

risk of food insecurity.[47] Family make-up or household composition also determines food insecurity, whereas single-parent households, especially those led by mothers, are more likely to be food insecure than two-parent households or households with no children.[19,47]

*Differences in Food Insecurity and Type II Diabetes Prevalence*

Within the Latino population, there is disproportionate exposure to food insecurity by certain characteristics. The group with the highest exposure to food insecurity is Latino immigrants, in 2014 (the most recent data of nativity available from the USDA), 24.4% of Latinos immigrants were food insecure compared to 18% of US-born Latinos.[42,49] Yet the prevalence of T2D has the opposite pattern: Latino immigrants have lower T2D prevalence than their US-born counterparts, a pattern that is attributed to the selectivity hypothesis of immigrant health.[50] This hypothesis argues that immigrants are selected on characteristics, such as better health patterns , that make them more likely to migrate compared to those left behind in the country of origin and that these characteristics contribute to better outcomes of post-migration health compared to the US-born. However, this health advantage tends to decrease with a longer duration of living in the United States.[50] There are multiple theories as to why there is a decrease in positive health patterns among Latino immigrants living in the United States over time. This decrease may be due to changing intrapersonal contexts, such as health behaviors, and erosion of protective factors due to acculturation and longer time spent in the United States.[51,52] It could also be due to interpersonal and social-environmental level factors such as discrimination.[51,52] T2D prevalence is patterned by the length of time in the US[53] and is highest among Latinos immigrants who have lived in the US for more than 15 years (18.8%) compared to recently

arrived immigrants who have lived in the US for less than 15 years (12.2%) and Latinos born in the US (14.5%).[53] The countervailing trends of food insecurity exposure and T2D suggest that the burden of T2D is not necessarily among those with the highest exposure to food insecurity. While counterintuitive, similar patterns have been found for obesity, with recent immigrants having the highest levels of food insecurity, but not displaying a significant association between food insecurity and obesity.[42] In contrast, food insecurity is associated with a higher likelihood of obesity among those born in the US and immigrants with longer duration in the US.[42]

*Food Insecurity and Stress*

Food insecurity has a known psychological component[54–56] and is associated with perceived stress in a dose-response relationship, with stress-related symptoms increasing as food insecurity status worsens.[57] The psychological response from food insecurity is well documented and may also be a pathway to T2D. Food insecure individuals are more likely to experience shame, guilt, anxiety, worry, and intensifying depressive symptoms.[58,59] Food insecure individuals with T2D report more mood disorders and depressive symptoms overall compared to their food-secure counterparts.[20] Food insecurity in and of itself is a unique type of stressor which may exacerbate physiological responses including cortisol secretion which plays a detrimental role in contributing to adiposity, insulin resistance,[60] and T2D.[61,62] Individuals with *prolonged* food insecurity also experience chronic stress. Prolonged food insecurity experienced as a chronic stressor promotes a stress response that results in allostatic load and dysregulation of the inflammatory and metabolic systems.[63]

*Food Insecurity and Dietary Intake*

Dietary intake, specifically diet quality, among Latinos is a potential pathway between food insecurity and T2D. Previous evidence supports the idea that food insecurity is associated with low diet quality and low consumption of fresh produce, which is in turn associated with poor glycemic control.[64] It has also been proposed that the reason why food insecurity is strongly associated with diabetes (even more so than other chronic illnesses) is that T2D is highly sensitive to diet.[25] In studies among Latino children those with higher severity of food insecurity had poor dietary intake and low nutritional quality.[65,66] The potential low-quality of diets among food insecure Latinos may foster this increased risk for T2D. In addition, those who are food-insecure may not have control of where they choose to live and most likely live in low-income neighborhoods with low availability of healthy foods.[67]

The cyclical nature of food insecurity was first discussed by Seligman and Schillinger.[68] Food-insecure individuals, especially those receiving public assistance such as food stamps, are incentivized to overconsume foods at the beginning of the month when their resources are higher and then under consume foods towards the end of the month once their budgets decrease.[69–71] One study, supporting this process, found that hospital admissions increased by 27% in the last week of the month compared to the first week among low-income individuals.[72] This inconsistent eating pattern or meal irregularity can have detrimental physiological effects on the endocrine system, hunger, and metabolism including a decrease in the thermic effect of food (increase in metabolic rate)[73] which is associated with insulin resistance.[74]A 2016 randomized-controlled trial among normal-

weight women found that meal irregularity was associated with increased glucose sensitivity and decreased thermic effect of food.[73]

Both food insecurity and dietary intake are influenced by *community-level* factors such as the local food environment as well as geography. Many rural communities lack large retailers and stores that provide access to fresh and nutritious foods, and are classified as "food deserts."[30] Residents of rural neighborhoods have the poorest access to supermarkets and healthy food options and thus are more likely to be food insecure and have poor dietary patterns compared to residents in suburban and urban neighborhoods.[30,75] The food environment can represent the physical presence of food, a person's proximity to food stores, the distribution (type, number, location) of food stores, markets, restaurants, and any physical entity where food may be obtained, or the connected system that allows access to food.[76] Swinburn et al. (2013) defined the food environment as the "collective physical, economic, policy and socio-cultural surroundings, opportunities and conditions that influence people's food and beverage choices and nutritional status."[77] The local food environment directly impacts one's diet and thus one's risk for T2D. Low accessibility to healthy foods is associated with an increased risk of adiposity[67,78] a precursor to insulin resistance and T2D.

Differences in the food environment can stem from geography but are also in government policies and incentives, and the legacy of such racist policies as redlining and segregation. Previous evidence has shown that racial/ethnic residential segregation, which is a commonly-used indicator for structural racism[79,80], has been associated with access to food (i.e. availability) and to cardiometabolic outcomes (both positive and negative) among Latinos.[81,82] In a 2009 study, Latino residents, living in neighborhoods of primarily

immigrant Latinos, reported poor neighborhood quality such as worse walkability, worse safety, and fewer recreational exercise resources , yet reported better food availability[83] Latino residential concentration, specifically Latino immigrant enclaves, may reinforce consumer demand[84] for more "traditional foods" that may be of higher quality relative to hyperpalatable and processed alternatives that are typically present in low-income neighborhoods.[82] Thus, *community-level* and structural factors such as segregation and neighborhood composition determine the local food environment. These factors not only influence the accessibility and affordability of foods but also the dietary intake of residents living in these communities. (Figure 1.1).

While logically it seems food insecurity is associated with dietary intake and diet quality, previous studies among Latinos, have only found differences in diet by food security status among children,[66,85] not adults. Research examining in-depth diet quality and intake among Latinos of different food security statuses is limited, but the few available studies have not observed dietary differences by food security status. Using the National Health and Nutritional Examination Survey (NHANES), Leung and Tester examined the relationship between food security status and diet quality using the Healthy Eating Index (HEI)-2015 as a measure of diet quality.[86] They found that among Hispanics there was no statistically significant difference in diet quality by food security status. Additionally, in a previous study in which I co-conducted examining Latinas, primarily Mexican Americans, in California, I found that controlling for dietary intake did not account for the relationship between food insecurity and obesity.[87] The measure of dietary intake utilized in this study was very limited and only focused on negative dietary behaviors such as the consumption of soda and fast food.[87] While these findings might lead to the conclusion that food security

status is not related to differences in diet among Latinos, it is also possible that current measures of dietary quality may not be sensitive enough to capture differences within the Latino population.

*Inconsistency in Measuring Dietary Intake*

One of the reasons why dietary intake may have not been found to be associated with food security status among Latinos is because the measurement and reporting of dietary intake are highly inconsistent due to the high variability of these instruments. Most studies utilize some form of food frequency questionnaires (FFQs) to measure food consumption. Conventional FFQs rely on a series of 24-hour recalls, 7-day diaries, or limited weighed food records. Instruments, analysis, and interpretations of nutritional studies utilizing this approach have measurement error, especially when FFQs are retrospective, rather than prospective, and when the range of the recall is longer than 24 hours.[88,89] However, FFQs still are the most widely utilized methods to measure dietary intake due to their convenience and low cost. When considering results from studies utilizing FFQs, respondents may also be subject to recall bias if they are asked to retrospectively report dietary intake. The validity of FFQs may be further threatened by social response or social desirability bias, since respondents may overly report consumption of healthy foods and underreport consumption of unhealthy foods.[89] Recall bias and social desirability bias may lead to non-significant or even erroneous findings. Estimates of dietary intake can be inconsistent due to the high variability of surveys measuring foods consumed over a given time. This is especially true in the literature examining the dietary intake of those experiencing food insecurity, for example, those who

acquire food from food banks and pantries.[90,91] These studies examining diet quality have utilized instruments such as 10-item block food frequency questionnaires to rapidly assess fruit and vegetable intake and do not provide detailed information about dietary intake. Studies examining dietary intake and quality, especially in the fields of nutritional epidemiology and population health, should utilize instruments that have been well documented as both valid and reliable and inclusive of different populations and diets.

*Neighborhood Social Cohesion*

*Interpersonal* and *community-level* factors can modify the relationship between food insecurity and cardiometabolic health outcomes. *Psychosocial* theory says that psychosocial factors generated by human interaction are modifying factors of disease susceptibility.[92] Cassel proposed that the "social environment" alters host susceptibility to disease.[93] The social environment theory posits that psychosocial and interpersonal assets such as social capital and social cohesion shape population health by altering norms and strengthening the bonds of society.[94,95] Community-level resources, such as those derived from neighborhood social cohesion, are important factors at the intersection of T2D[14], self-management of T2D,[96] and food security.[97–100] I place neighborhood social cohesion as a moderator of the relationship between food security status and T2D in my conceptual framework. Trusting neighborhood relationships can provide a resource for low-income families living in low-income neighborhoods, and this resource can help protect families from the experience of food insecurity[101] as well as improve safety and other aspects of health.[101] For example, perceived neighborhood social cohesion has been found to

moderate the relationship between social factors such as neighborhood deprivation[102] on health outcomes like depression.[102,103] Additionally, neighborhood social cohesion has had a significant independent effect on glycemic control among adults with T2D.[96] Neighborhood social cohesion may have a *modifying* effect of determinants leading to T2D and management.

However, individual perception of neighborhood social cohesion has also been conceptualized as having a direct relationship with food insecurity among low-income families living in low-income neighborhoods.[101] Martin et al. found that community-level social capital is associated with decreased risk of hunger, suggesting that social capital and social cohesion may be determinants of a household's food security status.[100] Another study found that higher neighborhood social cohesion is associated with higher food security among households with and without children in the U.S.[104] Contradicting these findings, there have been other studies where neighborhood social cohesion is not associated with reduced food insecurity.[105] Thus, the evidence on this topic is mixed. I conceptualize neighborhood social cohesion as a moderator, not a mediator because for mediation to occur, that would mean that neighborhood social cohesion would be determined by food security status.

These previously mentioned studies on cohesion and moderation are not specific to Latinos who may live in immigrant enclaves, or neighborhoods with a high immigrant composition.[106,107] Latinos are a diverse group with over a third of Latinos in the United States being foreign-born in 2017.[108] Latinos also make up the largest share of the foreign-born population in the United States.[109] As foreign-born Latinos settle in the United States, they frequently gravitate towards immigrant enclaves.[107,110] Latino immigrant enclaves

have been found to be protective against cardiometabolic outcomes.[111] Latino immigrant enclaves provide increased collective benefits for health including overall better access to healthy food[83] and the social network of immigrant Latinos may help sustain potential positive health behaviors practiced in the country of origin.[112,113] These resources can potentially make the moderating effect of neighborhood cohesion on the relationship between food insecurity and T2D more salient among Latinos. A 2017 qualitative study among food pantry recipients, who were primarily Spanish-speaking Latinos, found that recipients shared food and reciprocally provided social support to their food-insecure neighbors.[114] These findings suggest that neighborhood cohesion and social capital derived from neighborhood cohesion may serve as an important community-level resource that Latinos utilize as a coping mechanism when food insecure. This has not been tested empirically in quantitative data, however. High levels of neighborhood cohesion may be a proxy for instrumental support outside the household and act as a buffer against the adverse health effects of food insecurity including T2D.

## DISSERTATION OVERVIEW

The findings of this dissertation are presented in the subsequent three chapters. In chapter two, I examine the associations between food security status and T2D and food security status and self-management of T2D among Latinos. I also empirically test whether these associations differ by nativity and duration of residence in the United States. In chapter three, I derive dietary profiles among a nationally representative sample of Latinos and examine the association between food security status and these dietary profiles. In chapter four, I empirically test whether neighborhood social cohesion buffers the

association between food security status and T2D among Latinos. Lastly, in chapter five, I summarize my main findings and conclusions from chapters two through four.

*Chapter 2: Food Insecurity, Diabetes, and Diabetes Management Among Latinos: Differences by Nativity and Duration of Residence*

In chapter two, I examine whether there are differences in the association between food security status and T2D and food security status and self-management of T2D, by nativity status (born inside or outside the United States) and duration of residence in the United States, among Latinos. I utilize data from the 2012, 2013, 2014, 2015, and 2017 California Health Interview Surveys to examine the focal relationship between food security status and T2D among Latino adults who had a household income less than 200% of the federal poverty line (n=16,254). I also examine the relationship between food security status and self-management of diabetes among Latinos with T2D (n=2,284). I test whether these associations vary by nativity status and duration of residence among a representative sample of Latinos living in California.

*Chapter 3: Dietary Profiles of Latinas/os and Their Association with Food Security Status Using Data-Driven Exploratory Analyses*

In chapter three, I examine whether food security status is associated with different dietary profiles of Latinos. I utilize data from the 2013, 2014, 2015, 2016, 2017, and 2018 National Health and Nutrition Examination Survey to derive and identify dietary profiles of Latino adults (n=2,049) through exploratory factor analysis. Then I test whether the

dietary profiles derived from factor analysis are associated with different levels of food security status among a nationally representative sample of Latinos.

*Chapter 4: Food Insecurity and Type 2 Diabetes Among Latinos: Examining Neighborhood Cohesion as a Protective Factor*

In chapter four, I utilize data from the 2013, 2014, 2015, 2016, 2017, and 2018 National Health Interview Survey to examine whether neighborhood social cohesion moderates the relationship between food security status and T2D among a nationally representative sample of Latino adults (n=23,478).

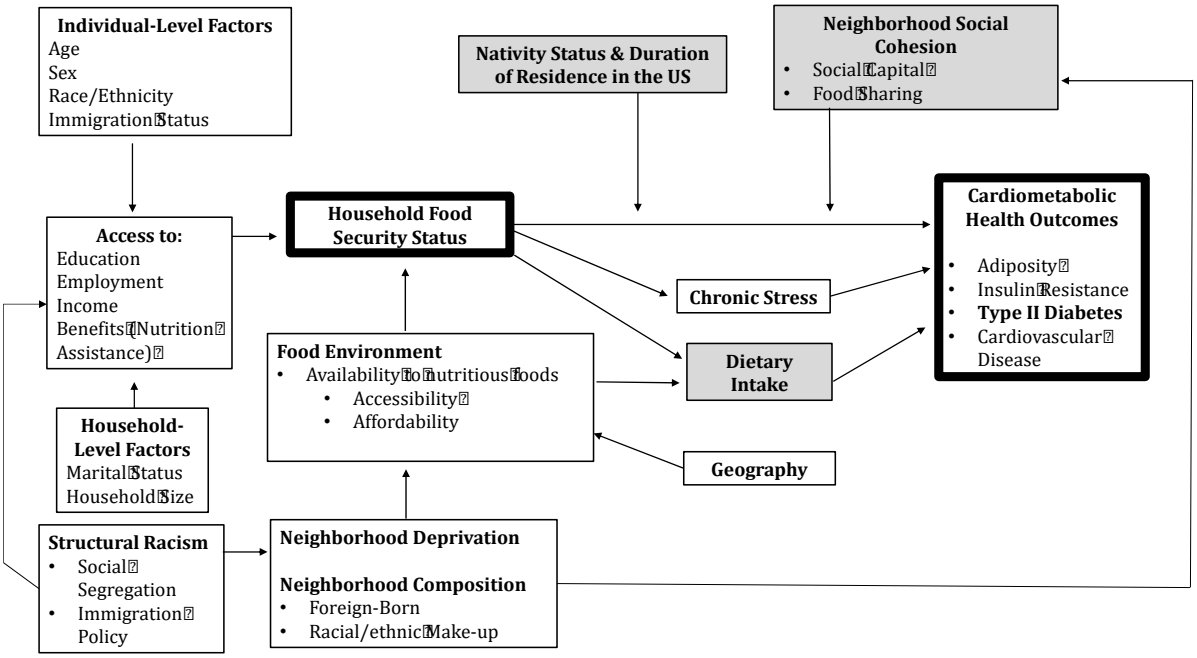


**Figure 1.1. Conceptual framework of food security status and Latino cardiometabolic health outcomes including type II diabetes**

# CHAPTER 2

## Food Insecurity, Diabetes, and Diabetes Management Among Latinos: Differences by Nativity and Duration of Residence[1]

The prevalence of diabetes in the United States (US) has continued to increase over the last 50 years; in 2019, estimated 28.5 million adults—or 8.7% of the U.S. population – had diagnosed diabetes.[1] Type 2 diabetes (T2D) accounts for about 95% of these diabetes cases.[2] Latinos are disproportionally affected by T2D, with a higher prevalence of diagnosed diabetes (12.1%) compared to non-Hispanic whites (7.4%).[2] This disparity continues to grow as people of Hispanic origin also have had a higher incidence of diabetes (8.4 per 1,000 persons) compared to Non-Hispanic whites (5.7 per 1,000 persons) during 2013–2015.[2]

Many social and environmental factors are associated with T2D diabetes. Among these, *food insecurity*, which is defined as lack of access by all people at all times to enough food for an active, healthy life, has been found to be an important risk factor.[7,18] Previous studies have found that individuals living in food-insecure households have a higher proportion of T2D when compared to their food-secure counterparts.[20–25] One study among low-income Americans found that participants with food insecurity were more than two times more likely to have T2D compared to their food secure counterparts after adjusting for sociodemographic factors, physical activity level, and body mass index.[17] Food insecurity appears to be a particularly important T2D risk factor for Latinos. Not only is the prevalence of food insecurity considerably higher among Latino households (18.0%) than

[1]Received a revise and resubmit decision from *Preventive Medicine Reports.*

the national average (11.8%), but the link between food insecurity and T2D is stronger compared to other racial/ethnic groups.[18] One study found that Latinas with very low food security were 3.3 more likely to have T2D even after controlling for employment, waist circumference, acculturation, and lifestyle characteristics.[23,17]

Food insecurity is also associated with poor glycemic control among diabetics.[115,116] The costs of glucose monitoring strips and prescription medication compete with costs for basic needs such as food and housing. Competing demands have been reported as a barrier to adherence and diabetes management among diabetes patients, regardless of race/ethnicity.[117] One study among chronically-ill adults found that medication underuse due to cost was significantly higher among food insecure individuals compared to food secure individuals[118] Similarly, a study among adults with diabetes found that food insecure participants had almost six times higher odds of scrimping their medications compared to their food secure counterparts.[119] Food-insecure individuals are less likely to fill their prescription[120], use new needles, and monitor their glucose levels regularly[58,121,122] since these compete with buying healthy foods and paying rent.[25,123,124] Lastly, food insecure individuals have reported difficulty affording a diabetic diet, have a lower diabetes-specific self-efficacy, and have higher emotional distress related to diabetes.[115] Among diabetics, Latinos also seem to have poorer control of their condition compared to other racial/ethnic groups, as measured by HbA1c value.[125,126]

Latinos' disproportionate exposure to food insecurity puts them at a greater risk for T2D and poor management outcomes. Yet this association may not be uniformly experienced within the larger Latino population. Food insecurity is more prevalent among Latinos immigrants (24.4%) than their US born counterparts (18%).[49] T2D prevalence is

further patterned by the length of time in the US.[53] The prevalence of T2D is highest among immigrants who have lived in the US for more than 15 years (18.8%) compared to recent immigrants (12.2%) and Latinos born in the US (14.5%).[53] Although Latino immigrants have the lowest levels of T2D, they also have the highest levels of food insecurity.[49] Similar patterns have been found for obesity, with recent immigrants having the highest levels of food insecurity, but not displaying a significant association between food insecurity and obesity.[42] In contrast, food insecurity is associated with higher likelihood of obesity those born in the US and immigrants with longer duration in the US.[42] Although there are differences by nativity and duration when examining patterns of food insecurity and T2D separately, this chapter examines whether the relationship between food insecurity and T2D differs by these factors among Latinos as well.

Currently, there are no studies examining the associations between food insecurity and diabetes prevalence or glycemic control among Latinos by nativity or duration of stay in the US. The counterintuitive trends of T2D prevalence and food insecurity among Latinos by nativity and duration underscore the importance of examining nativity and duration when examining the relationship between food insecurity, T2D, and management of T2D. In this chapter, I examine the extent to which the relationship between food insecurity and T2D, as well as diabetes management, differs by nativity and duration of residence among Latinos living in California.

## METHODS

I analyzed data from the 2012-2017 Adult California Health Interview Survey (CHIS).[127] The CHIS is a cross-sectional, random digit dial telephone survey, representative of California's noninstitutionalized population, and is the largest state health survey in the

nation. The CHIS is administered in multiple languages and oversamples minority racial/ethnic groups to ensure adequate numbers of participants from a variety of racial/ethnic backgrounds participate in the survey. I combined six waves of data to ensure a sufficient sample of Latino adults born in and outside of the US (total Latinos: n=27,988). I further restricted the sample to those who had a household income less than 200% of the federal poverty line, as this was the income threshold for the CHIS food insecurity questionnaire (n=16,254). In the analyses in which I examined diabetes management, the sample was further restricted to those with T2D (n=2,284).

Measures

*Food Security*

Food security was measured using the validated United States Department of Agriculture Household Food Security Survey Module six-item form.[67] Raw scores ranging from 0-6 were generated by the affirmative responses to the questions. Food security status was classified according to the US Department of Agriculture's (USDA) guidelines: 0–1, high or marginal food security; 2–4, low food security; 5–6, very low food security.

*Diabetes*

T2D was measured by two questions, "Has a doctor ever told you have diabetes?" and "type 1 or type 2 diabetes?". T2D was distinguished if respondents answered "yes" and specified Type 2 diabetes in their responses. Less than 4% (n=148) of Latinos reported having been diagnosed with diabetes, but not specifying which type (type 1 or type 2). These cases were classified as not having T2D.

*Diabetes Management*

Diabetes management was measured by the question: "How confident are you that you can control and manage your diabetes?" This was only asked of respondents who had been told by a physician they had diabetes. Response items included very confident, somewhat confident, not too confident/not at all confident. For the purpose of my analyses, I dichotomized the categories to "very confident" versus all others.

*Nativity/US Duration*

The CHIS uses a categorical variable to measure the duration of time living in the US: <5 years, 5-9 years, 10-14 years, 15+ years. In addition, The CHIS measures nativity by asking respondents if they were born in the US: yes/no. I combined both of these measures into one categorical variable to measure nativity and duration of time living in the US: Born in the US (reference), FB with <10 years US duration, and FB 10+ years US duration. There were no missing values for these variables. I used nativity/duration combined variable when examining diabetes prevalence. However, for the diabetes management outcome, I used the nativity variable of born within or outside the US due to a smaller sample size.

*Covariates*

In multivariable analyses, I controlled for age in years; education (less than high school grad, high school grad, some college/college grad); income (<20,000, 20,000-29,000, and 30,000+); gender (female or male); health insurance (does not have health insurance, has health insurance); and family type (single no children, married no children, married with children, single with children).

Statistical Analysis

I calculated descriptive statistics stratified by nativity/US duration. I then conducted a series of logistic regressions. I first established the unadjusted association between food

security status and the diabetes outcome (prevalence or management), then controlled for all covariates. Lastly, I stratified the models by duration/nativity in the US (T2D prevalence) or nativity (T2D management), to examine differences by subgroups and tested whether these coefficients were different from one another using an adjusted Wald test.

I performed all statistical analyses using STATA/IC 14 (StataCorp LP, College Station, TX, USA). I incorporated replicate weights using jackknife replications to account for the complex sampling design and adjusted the weights for combining across six survey waves.

## RESULTS

### Sample Characteristics

A higher percentage of Latinos living in the US for 10 years or more reported having T2D (13.7%) compared to Latinos born in the US (8.2%) and those living here in the US for less than 10 years (3.3%) (Table 1). Latinos born in the US had the highest levels of high/very high food security (62.6%), while immigrant Latinos had similar levels, regardless of US duration (51.9% among longer stay, 51.6% among recent). However, the percentage of Latinos reporting very low food security was similar across all duration/nativity categories. Latinos born in the US had higher educational attainment and income compared to foreign-born Latinos. Among Latinos with T2D, a higher percentage of foreign-born Latinos reported having better management of their diabetes (56.2 % among longer stay, 52.4% among recent) than US-born Latinos (45.8), despite also having lower rates of health insurance.

Multivariable Results

*T2D Prevalence*

In Table 2, my first model shows that Latinos had a higher odds of having T2D if they reported low food security (OR=1.36; 95% CI:1.11-1.67) or very low food security (OR=1.47; 95% CI:1.11-1.94) compared to their food secure counterparts. These differences became stronger after controlling for covariates (low food insecurity: OR=1.44; 95% CI:1.14-1.83; very low food security: OR=1.87; 95% CI:1.33-2.61). In models stratified by nativity/duration, Latinos born in the US had a higher odds of having T2D if they reported low food security (Model 3: OR=1.60; 95% CI:1.02-2.52) or very low food security (OR=2.37; 95% CI:1.45-3.86) compared to food secure US Born Latinos. However, among Latinos living in the US for less than 10 years, there was no statistically significant association between food security status and diabetes prevalence. Lastly, among Latinos living in US for 10 years or more, those who reported low food security (OR=1.48; 95% CI:1.12-1.97) or very low food security (OR=1.78; 95% CI:1.15-2.76) had a higher odds of having T2D compared to their food secure counterparts.

*Diabetes Management*

Table 3 provides the results for the diabetes management outcomes. In the unadjusted model, Latinos with T2D had a lower odds of reporting proper management of their diabetes if they had low food security (Model 1: OR=0.62, 95% CI:0.42-0.92) or very low food security (OR=0.45, 95% CI:0.28-0.73) compared to those who were food secure. In Model 2, these associations remained statistically significant after controlling for covariates. In models stratified by nativity, Latinos born outside the US had a lower odds of reporting that they managed their T2D well if they reported low security (Model 3:

OR=0.54; 95% CI:0.34-0.86) or very low food security (OR=0.36; 95% CI:0.17-0.74) compared to their food secure counterparts. Finally, among Latinos born in the US, there was no association between food security status and diabetes management (Model 4).

## DISCUSSION

I examined if food security was associated with diabetes prevalence and diabetes management among Latinos living in California. I also explored if these associations differed by nativity and duration of residence in the US. I found that Latinos had a higher odds of diabetes if they reported low food security and very low food security, in a graded fashion, compared to Latinos who were food secure. Latinos born in the US and foreign-born Latinos living in the US for 10 years or greater exhibited a similar trend, with food insecurity associated with higher odds of T2D. However, this relationship was not present among Latinos living in the US less than 10 years.

My findings suggest that food insecurity is an important factor that influences T2D susceptibility as Latino immigrants live longer in the US. Responses to food insecurity, especially pertaining to dietary intake, may differ between recent and longer stay Latino immigrants. For example, like many other socio-economically disadvantaged groups in the US, food insecure Latino immigrants with longer US duration may cope with their food insecurity similarly as US born Latinos by selecting and consuming cheap, low-quality, energy-dense foods.[128] These types of foods exacerbate weight gain, insulin resistance, and thus risk of T2D. In contrast, recent Latino immigrants experiencing food insecurity may consume staple foods that are similar to their country of origin, including corn tortillas, beans, eggs, and tomatoes.[129] buffering the negative effects of food insecurity. In general,

independent of food insecurity, longer stay Latino immigrants may have worse dietary intake than recent immigrants.[43,130]

Alternatively, food insecurity may act as an independent stressor which exacerbates insulin resistance and thus T2D. Both acute[131] and chronic stress[132,133] have been found to be associated with glucose metabolism and insulin resistance. Recent research has found that among Latinos with T2D, inflammation and stress biomarkers mediate the association between household food insecurity and insulin resistance.[134] The psychological stressful state of being food insecure may increase inflammation as well as cortisol levels, resulting in these metabolic outcomes. Although recent immigrants experience higher levels of food insecurity, longer stay immigrants potentially have longer exposure to food insecurity and thus higher levels of chronic stress.

The findings from this study are significant because they imply that as immigrant Latinos live longer in the United States, their odds of having T2D when food insecure is similar to Latinos born in the United States. This can be attributed to both the long latent period of T2D as well as health selection among migrants. Although recent immigrant Latinos report higher rates of food insecurity, they are less likely to have T2D. Latino immigrants have lower T2D prevalence than their US-born counterparts, a pattern that is attributed to the selectivity hypothesis of immigrant health.[50] This hypothesis argues that immigrants are selected on characteristics, such as better health patterns, that make them more likely to migrate compared to those left behind in the country of origin and that these characteristics contribute to better outcomes of post-migration health compared to the US-born. However, this health advantage tends to decrease with a longer duration of living in the United States.[50] My findings align with this theory. Similar patterns have been found for

obesity, with recent immigrants having the highest levels of food insecurity, but not displaying a significant association between food insecurity and obesity.[42] In contrast, food insecurity is associated with a higher likelihood of obesity among those born in the US and immigrants with longer duration in the US.[42]

In terms of diabetes management, Latinos with T2D had lower odds of managing their diabetes well if they had low or very low food security, compared to their food secure counterparts. However, after stratifying by nativity, Ifound this relationship only existed among foreign-born Latinos. These analyses did not examine differences among immigrants by duration of residence because of small samples sizes. Based on the distribution of T2D the sample, the results for T2D management are mostly drawn from the longer stay immigrant Latinos. These findings on diabetes management run counter to my findings on the relationship of food insecurity and diabetes prevalence; US-Born Latinos were more likely to have T2D when food insecure, but no association was seen between food insecurity and T2D management among US-Born. One reason why there was worse management among food insecure immigrant Latinos, but not food insecure US-born Latinos, may be related to the utilization of health care services. Past research has found that immigrant Latinos are less likely to utilize health care services, especially private and primary care clinic visit.[135]

There are limitations to this study. First, this study utilizes cross-sectional data which cannot determine causality or directionality of the models. Second, all of the measures were self-reported and thus are at risk of recall and social desirability biases.[30] T2D was measured by a respondent reporting whether a physician told them they have diabetes. By nature, this form of measurement excludes respondents who may not have

access to a physician, and may thus be undiagnosed. I controlled for health insurance status in my models to possibly adjust for this. Individuals with undiagnosed diabetes are less likely to have regular access to care and more likely to be low-income and represent a high proportion of the Latino population in the US.[138] This may result in underestimating Latinos with T2D, thus making my findings conservative. Diabetes management was measured by asking respondents how confident they are in controlling and managing their diabetes. It is possible that people reported being confident about their management even though they may have poor control. However, this is why I decided to code the variable as "very confident" versus all other responses to minimize social desirability bias. Future studies should utilize longitudinal designs and use clinical measurements to determine diabetes status and diabetes management.

## CONCULUSIONS

Future research should focus on pathways between food insecurity and T2D and T2D management, such as dietary pathways, and how these pathways might vary among Latinos of different nativity and duration of residence in the US. This research will be useful in developing targeted interventions aimed at reducing T2D among Latinos and increasing proper management among Latinos with T2D. Future interventions should target recently arrived food-insecure Latino immigrants to prevent the onset of T2D by reducing food insecurity. Additionally, interventions for immigrant Latinos with T2D, should address unmet material needs, such as food insecurity, in order to increase self-management of T2D.

**Table 2.1: Weighted Sample Description, California Health Interview Survey 2012-2017[a] Latinos Adults, n=16,254**

| | Native Born (n=5,475) | Living in US <10 Years (n=1,173) | Living in US ≥10 Years (n=9,606) |
|---|---|---|---|
| **Demographics** | | | |
| Mean Age | 31.3 | 31.6 | 44.9 |
| Mean Age of those with T2 Diabetes+ | 53.2 | 49.3 | 54.7 |
| Gender | | | |
| Female | 55.2 | 57.1 | 53.5 |
| Male | 44.8 | 42.9 | 46.5 |
| Education, % | | | |
| Less than High School | 17.3 | 56.7 | 66.1 |
| High School Diploma | 72.3 | 33.6 | 29.6 |
| Some College+ | 10.4 | 9.7 | 4.4 |
| Household total Annual Income, % | | | |
| $0-19,999 | 34.6 | 47.9 | 36.2 |
| $20,000-29,000 | 25.0 | 27.2 | 28.7 |
| $30,000+ | 40.4 | 24.9 | 35.2 |
| Family Type, % | | | |
| Single No Kids | 61.3 | 38.7 | 27.5 |
| Married No Kids | 7.4 | 7.9 | 19.8 |
| Married with Kids | 18.4 | 40.1 | 41.4 |
| Single with Kids | 12.8 | 13.3 | 11.2 |
| Currently Has Health Insurance, % | 80.9 | 54.2 | 70.5 |
| **Food Security Status, %** | | | |
| High/Marginal Food Security | 62.6 | 51.6 | 51.9 |
| Low Food Security | 23.8 | 35.4 | 34.8 |
| Very Low Food Security | 13.6 | 13.1 | 13.3 |
| **Diabetes and Management** | | | |
| Type 2 Diabetes Prevalence, % | 8.2 | 3.3 | 13.7 |
| Prevalence of Managing Diabetes Well+ | 45.8 | 52.4 | 56.2 |

[a]Sample is limited to adult respondents who identify as Latino and live under 200% of the poverty line.
+ Among those with Type 2 Diabetes (n=2,284)

**Table 2.2: Odds of Self-Reported Type 2 Diabetes among Latino Adults, California Health Interview Survey 2012-2017[a] n=16,254**

| | Model 1<br>Unadjusted Main Effects of Food Insecurity | | | Model 2<br>Food Insecurity, Main Effects of Duration, Controls | | | Model 3<br>Food Insecurity, Controls among US Born | | | Model 4<br>Food Insecurity, Controls among <10 Year Immigrants | | | Model 5<br>Food Insecurity, Controls, Among 10 Year+ Immigrants | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **OR** | **[95% CI]** | | **OR** | **[95% CI]** | | **OR** | **[95% CI]** | | **OR** | **[95% CI]** | | **OR** | **[95% CI]** | |
| **Food Security Status** | | | | | | | | | | | | | | | |
| High / Marginal Food Security | | | | | | | | | | | | | | | |
| Low Food Security | 1.36** | 1.11 | 1.67 | 1.44** | 1.14 | 1.83 | 1.60* | 1.02 | 2.52 | 0.56 | 0.11 | 2.75 | 1.48** | 1.12 | 1.97 |
| Very Low Food Security | 1.47** | 1.11 | 1.94 | 1.87** | 1.33 | 2.61 | 2.37** | 1.45 | 3.86 | 1.07 | 0.20 | 5.76 | 1.78** | 1.15 | 2.76 |
| **Duration in the United States** | | | | | | | | | | | | | | | |
| Born in US | | | | | | | | | | | | | | | |
| <10 Years | | | | 0.44* | 0.23 | 0.82 | | | | | | | | | |
| 10 Years+ | | | | 0.84 | 0.64 | 1.11 | | | | | | | | | |
| **Covariates** | | | | | | | | | | | | | | | |
| Age | | | | 1.06** | 1.05 | 1.07 | 1.07** | 1.06 | 1.08 | 1.08** | 1.05 | 1.12 | 1.05** | 1.04 | 1.06 |
| Gender | | | | | | | | | | | | | | | |
| Female | | | | | | | | | | | | | | | |
| Male | | | | 1.27 | 0.92 | 1.75 | 1.29 | 0.86 | 1.93 | 1.12 | 0.32 | 3.91 | 1.28 | 0.83 | 1.98 |
| Year | | | | | | | | | | | | | | | |
| 2012 | | | | | | | | | | | | | | | |
| 2013 | | | | 1.24 | 0.89 | 1.74 | 2.09* | 1.14 | 3.84 | 0.08** | 0.02 | 0.38 | 1.13 | 0.76 | 1.68 |
| 2014 | | | | 0.97 | 0.7 | 1.35 | 2.04* | 1.05 | 3.95 | 0.50 | 0.09 | 2.93 | 0.77 | 0.52 | 1.13 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2015 | 1.07 | 0.78 | 1.48 | 1.42 | 0.76 | 2.63 | 0.30 | 0.06 | 1.67 | 1.02 | 0.70 | 1.50 |
| 2016 | 1.1 | 0.77 | 1.58 | 0.98 | 0.50 | 1.93 | 0.44 | 0.05 | 4.06 | 1.19 | 0.79 | 1.79 |
| 2017 | 1.14 | 0.8 | 1.62 | 0.96 | 0.45 | 2.04 | 1.61 | 0.03 | 83.9 | 1.24 | 0.82 | 1.88 |
| Educational Attainment | | | | | | | | | | | | |
| Less than High School | | | | | | | | | | | | |
| High School Diploma | 0.72* | 0.56 | 0.94 | 0.69 | 0.41 | 1.16 | 0.30 | 0.05 | 1.78 | 0.76+ | 0.57 | 1.02 |
| Some College + | 0.62+ | 0.38 | 1.01 | 0.71 | 0.26 | 1.90 | 0.44 | 0.03 | 5.66 | 0.58+ | 0.32 | 1.06 |
| Income Category | | | | | | | | | | | | |
| Less than 20,000 | | | | | | | | | | | | |
| 20000-29999 | 1.05 | 0.81 | 1.36 | 0.94 | 0.60 | 1.49 | 0.8 | 0.08 | 7.97 | 1.08 | 0.81 | 1.46 |
| 30,000+ | 0.97 | 0.72 | 1.31 | 1.39 | 0.78 | 2.46 | 0.34 | 0.01 | 7.91 | 0.86 | 0.60 | 1.23 |
| Family Type | | | | | | | | | | | | |
| Single No Children | | | | | | | | | | | | |
| Married No Children | 1.44* | 1.08 | 1.92 | 1.67 | 0.84 | 3.3 | 0.79 | 0.20 | 3.15 | 1.36+ | 1.00 | 1.86 |
| Married with Children | 1.03 | 0.78 | 1.38 | 1.43 | 0.86 | 2.37 | 0.30 | 0.06 | 1.6 | 0.91 | 0.62 | 1.33 |
| Single with Children | 0.83 | 0.55 | 1.26 | 1.46 | 0.73 | 2.94 | 0.05* | 0.00 | 0.78 | 0.62+ | 0.37 | 1.05 |
| Receiving Health Insurance | 1.58** | 1.20 | 2.07 | 1.27 | 0.63 | 2.56 | 0.92 | 0.20 | 4.33 | 1.72** | 1.24 | 2.39 |

[a]Sample is limited to respondents who identify as Latino and live under 200% of the poverty line.

Test of significance= +p<0.1 *p<.05 **p<.01

**Table 2.3: Table 3 Odds of Managing Diabetes Well among Latino Adults, California Health Interview Survey 2012-2017[a] n=2,284**

| | Model 1<br>Unadjusted Main Effects of Food Insecurity | | | Model 2<br>Food Insecurity, Main Effects of Nativity, Controls | | | Model 3<br>Food Insecurity, Control, Foreign-Born | | | Model 4<br>Food Insecurity, Control, US Born | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **OR** | **[95% CI]** | | **OR** | **[95% CI]** | | **OR** | **[95% CI]** | | **OR** | **[95% CI]** | |
| **Food Security Status** | | | | | | | | | | | | |
| High/Marginal Food Security | | | | | | | | | | | | |
| Low Food Security | 0.62* | 0.42 | 0.92 | 0.56** | 0.36 | 0.86 | 0.54** | 0.34 | 0.86 | 0.72 | 0.31 | 1.72 |
| Very Low Food Security | 0.45** | 0.28 | 0.73 | 0.46** | 0.26 | 0.83 | 0.36** | 0.17 | 0.74 | 0.82 | 0.32 | 2.09 |
| **Born in US** | | | | 0.63+ | 0.38 | 1.04 | | | | | | |
| **Covariates** | | | | | | | | | | | | |
| Age | | | | 1.00 | 0.98 | 1.02 | 1.01 | 0.99 | 1.04 | 0.98 | 0.96 | 1.01 |
| Gender | | | | | | | | | | | | |
| Female | | | | | | | | | | | | |
| Male | | | | 1.46* | 1.03 | 2.07 | 1.69* | 1.07 | 2.66 | 0.98 | 0.41 | 2.34 |
| Year | | | | | | | | | | | | |
| 2012 | | | | | | | | | | | | |
| 2013 | | | | 1.20 | 0.67 | 2.12 | 0.92 | 0.45 | 1.91 | 2.28+ | 0.87 | 5.97 |
| 2014 | | | | 1.05 | 0.59 | 1.89 | 1.08 | 0.52 | 2.24 | 1.15 | 0.43 | 3.07 |
| 2015 | | | | 0.98 | 0.54 | 1.80 | 0.89 | 0.48 | 1.64 | 1.18 | 0.32 | 4.40 |
| 2016 | | | | 1.24 | 0.67 | 2.29 | 1.08 | 0.54 | 2.16 | 1.62 | 0.44 | 5.96 |
| 2017 | | | | 1.07 | 0.52 | 2.20 | 0.77 | 0.36 | 1.67 | 2.47 | 0.56 | 10.89 |
| Educational Attainment | | | | | | | | | | | | |
| Less than High School | | | | | | | | | | | | |
| High School Diploma | | | | 0.95 | 0.61 | 1.48 | 1.03 | 0.59 | 1.79 | 0.68 | 0.28 | 1.62 |
| Some College + | | | | 1.31 | 0.52 | 3.28 | 1.09 | 0.40 | 2.98 | 1.09 | 0.20 | 5.96 |
| Income Category | | | | | | | | | | | | |
| Less than 20,000 | | | | | | | | | | | | |
| 20000-29999 | | | | 0.93 | 0.59 | 1.48 | 0.92 | 0.54 | 1.58 | 1.02 | 0.32 | 3.23 |
| 30,000+ | | | | 0.73 | 0.38 | 1.43 | 0.73 | 0.31 | 1.68 | 1.35 | 0.38 | 4.82 |
| Family Type | | | | | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Single No Children | | | | | | | | | |
| Married No Children | 0.94 | 0.59 | 1.50 | 0.78 | 0.41 | 1.47 | 1.49 | 0.50 | 4.45 |
| Married with Children | 0.75 | 0.40 | 1.40 | 0.87 | 0.37 | 2.04 | 0.38 | 0.09 | 1.65 |
| Single with Children | 0.48+ | 0.22 | 1.04 | 0.58 | 0.20 | 1.64 | 0.46 | 0.12 | 1.79 |
| Receiving Health Insurance | 1.21 | 0.72 | 2.02 | 0.97 | 0.51 | 1.87 | 5.08+ | 0.96 | 27.30 |

[a]Sample is limited to respondents who identify as Latino Adults, live <200% federal poverty line and have Type 2 Diabetes

Test of significance= +p<0.1 *p<.05 **p<.01

# CHAPTER 3

# Dietary Profiles of Latinas/os and Their Association with Food Security Status Using Data-Driven Exploratory Analyses

## INTRODUCTION

### Food Insecurity, Diet, and Cardiometabolic Outcomes among Latinos/as

Food insecurity, or the lack of access to enough food for an active, healthy life, is associated with poor health outcomes including cardiometabolic conditions such as type 2 diabetes and obesity[20–24,87,139,140], particularly among Latinos.[22,23,87] Additionally, the prevalence of food insecurity is considerably higher among Latino households (17.0%) than non-Hispanic whites (7.0%), and the national average (11.0%).[141] Previous empirical evidence has shown that food security status is associated with chronic disease including cardiometabolic conditions, whereas high levels of food insecurity are associated with negative outcomes[20,21,39,40,87]. Among these studies that have focused on Latinos or subgroups (e.g. Mexican Americans and Puerto Ricans), few pathways have been empirically tested.[64,134,142]

Dietary intake and quality have been posited as a possible mediating pathway between food security status and cardiometabolic health outcomes.[39,64,143] Previous evidence has shown that food insecurity is associated with low-quality diets and lower consumption of produce including fruits and vegetables.[64] In addition, those who are food-insecure are more likely to experience resource and economic deprivation and live in low-income neighborhoods with low accessibility (both availability and affordability) to high-quality foods.[67] Low accessibility to healthy foods is associated with an increased risk of

adiposity and with poor glycemic control.[6467,78] There are several theoretical frameworks presented throughout the food insecurity literature that link food insecurity with poorer diets. The energy-density framework proposes that food insecure consumers are more likely to select energy-dense and hyperpalatable foods as a deliberate strategy to maximize calories at a reduced cost.[144,145] Other frameworks emphasize the psychological component of food insecurity and conceptualize it within a stress and coping framework. [54–56] Individuals experiencing prolonged food insecurity report more chronic stress than their food-secure counterparts and the link between food insecurity and perceived stress increases in a dose-response pattern.[146] Lararia proposes a theoretical framework where food insecurity *is experienced as a chronic stressor*, promotes a stress response, which results in a preference for and consumption of highly palatable foods.[61] Physiological responses to the stress induced by food insecurity, such as the elevation of cortisol, have been found to increase adiposity[39] and compensatory eating behaviors such as the selection of high-caloric and palatable foods over fresh produce.[147,148] This pathway suggests that individuals experiencing food insecurity may rely on the consumption of high-caloric-dense foods to cope with their food insecurity.

While the association between food insecurity and cardiometabolic conditions has been consistently established, including among Latinos, diet does not seem to vary by food security status. Research examining in-depth diet quality and intake using rigorous dietary measures of Latinos of different food security statuses is limited, but the few available studies have not observed dietary differences by food security status. Using the National Health and Nutritional Examination Survey (NHANES), Leung and Tester examined the relationship between food security status and diet quality using the Healthy Eating Index

(HEI)-2015 as a measure of diet quality.[86] They found that among Hispanics and Non-Hispanic Blacks, there was no statistically significant difference in diet quality by food security status, but that among Non-Hispanic Whites and Asians, food insecurity was associated with poorer diet quality. Likewise, a study examining Latinas in California, primarily Mexican Americans, found that controlling for dietary intake did not account for the association between food insecurity and higher obesity.[87] However, controlling for the affordability of fresh produce did account for the association. The measure of dietary intake in the study was very limited, however, and only focused on negative dietary behaviors such as the consumption of soda and fast food.[87]

**Measuring Diet Quality Among Latinos**

While these findings might lead to the conclusion that food security status is not related to differences in diet among Latinos, it is also possible that current measures of dietary quality may not be sensitive enough to capture differences within the Latino population. Diet quality is usually calculated using a priori indices based on dietary recommendations.[149] One common measure, the Healthy Eating Index (HEI), .[150] is scored out of 100 points from 13 individual components: total fruits, whole fruits, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood, and plant proteins, fatty acids, refined grains, sodium, added sugars, and saturated fats.

While the HEI-2015 has been evaluated and has demonstrated both reliability and validity of measuring diet quality of the United States population overall consistent with the DGA recommendations, there are aspects of the scoring criteria that may not accurately capture the dietary quality among Latinos.[150] For instance, the scoring criteria heavily weighs dairy consumption towards the overall score. For many Latino subgroups, however,

lactose persistence (ie, the ability to digest milk and other dairy products during adulthood) is low among certain populations, such as the adult populations in Mexico (30%), and adult populations in some South American counties (20% in Colombia, 6% in Peru, 38% in Chile, 37% in Brazil, and 30% in Uruguay).[151] This is considerably lower than the prevalence of lactose persistence of White American adults (83-93%). This may also explain why more non-Hispanic Whites meet the Dietary Guidelines for Americans recommended intake for dairy compared to non-Hispanic Blacks and Mexican-Americans.[152]

The null findings between food security status and HEI-2015 from previous research and the limitations of the HEI-2015 due to scoring procedures, influenced my decision to examine dietary patterns and dietary profiles of Latino/as using a posteriori approach through data-driven exploratory methods.

**Aims of this study**

Detailed dietary consumption has not been thoroughly examined at the population level among Latinos. Additionally, previous research examining the relationship between dietary intake and food security status has been limited to less than rigorous food frequency questionnaires or utilized measures of diet quality that may not be as inclusive for Latinos. This study utilizes standardized measures of food groups (United States Department of Agriculture's Food Patterns Equivalent Database from the *What We Eat in America* component of the NHANES) and exploratory factor analysis to identify dietary profiles of a nationally representative sample of Latinos. I ask the following research questions and examine them through an a posteriori approach[149]: 1) which dietary patterns, or profiles, are most common among Latinos in the United States? 2) how does

food security status relate to these dietary profiles?

## METHODS

### Study population

I used data from the National Health and Nutritional Examination Survey (NHANES)[153] from 2013 to 2014, 2015 to 2016, and 2017 to 2018. The NHANES is a publicly available data set from the National Center for Health Statistics, a division of the Center for Disease Control and Prevention. It is designed to assess both the health and nutritional status of adults and children in the United States.[154] The NHANES consists of a series of interviews, physical examinations, and laboratory measurements that is representative of the noninstitutionalized population in the United States. The sample is selected using a complex, stratified, multistage probability cluster design. As part of the nationwide survey, which involves about 5000 persons each year, participants in this study completed the Household Adult Questionnaire and the Dietary Food Frequency Questionnaire.[154]

### Analytic sample and Weighting

I restricted my analytic sample to adults aged 18 and older and those who identified as Mexican American or other Hispanic when asked about their race and ethnicity (n=4,585). I further restricted to those participants who had completed two separate 24-hour reliable dietary recalls resulting in a sample size of 2,376. Reliable dietary recalls must meet certain criteria as defined by the NHANES which include assessing the quality and completeness of a survey's participant's response to the dietary recall section. Finally, I further restricted to those participants who had data for all demographic questions on age, sex, income, level of education, and nativity and duration of residence in the United States

resulting in a total sample size of 2,049 participants. Because NHANES studies tend to oversample underrepresented ethnicities, NHANES provides guidelines for sample weighting and stratification in the data set. I used the appropriate sampling weights in my statistical analyses to account for the unequal probability of selection, noncoverage, and nonresponse bias.

**Dietary Profiles**

Dietary intake was assessed in the NHANES study by two separate dietary recalls. All NHANES participants are eligible for two, 24-hour dietary recalls. The first dietary recall is collected in-person in the Mobile Examination Center (MEC), and the second recall, which only a subset of participants complete, is collected by telephone 3 to 10 days later. Both recalls are offered in English and Spanish as well as other languages.[155] Dietary intake is first weighted across the two dietary recall days in order to provide more precise estimates of consumed portions[156], then it is disaggregated to ingredients using the Nutrient Database for Dietary Studies, which provides nutrient compositions for about 8700 foods and in WWEIA, NHANES.[157] Dietary data is then converted into the respective amounts of food patterns equivalents present in them[158] and assigned to a food pattern listed in the Food Patterns Equivalent Database (FPED). This conversion process results in a total of 37 FPED food groups or components.

For this study, I identified and used mutually exclusive food groups (29 FPED components). I excluded food groups that were total or aggregate groups that consisted of two or more food groups. The excluded total or aggregate groups were: Total Fruits; Total Vegetables; Total Red and Orange Vegetables; Total Starchy Vegetables, Total Grains; Total Protein Foods; Total Meat, Poultry, and Seafood; and Total Dairy. The 29 FPED components

used in this study were: Citrus, Melons, and Berries; Other Fruits; Fruit Juice; Dark Green Vegetables; Tomatoes; Other Red and Orange Vegetables; Potatoes; Other Starchy Vegetables; Other Vegetables; Beans and Peas (computed as vegetables); Whole Grains; Refined Grains; Meat; Cured Meat; Organ Meat; Poultry; Seafood High in Omega-3 Fatty Acids; Seafood Low in Omega-3 Fatty Acids; Eggs; Soy Products; Nuts and Seeds; Beans and Peas (computed as protein foods); Milk; Yogurt; Cheese; Oils; Solid Fats; Added Sugars; and Alcoholic Drinks.

I then used exploratory factor analysis, a data reduction technique to identify unique dietary profiles within the 29 food groups.[159] This method reduced the food groups (i.e., indicators) to a few mutually exclusive profiles (i.e., factors) while minimizing the loss of information.[159] Prior to conducting principal component analysis, I generated a correlation matrix to identify the correlations among the 29 food groups. I evaluated the appropriateness of the data for factor analysis based on the value of Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity (homogeneity of variance). The KMO measure, which represents the adequacy of sample size, compares the value of partial correlation coefficients against the total correlation coefficients.

I then used principal component analyses (PCA) to identify unique dietary factors from the 29 food groups. I conducted orthogonal rotation with the varimax option to derive non-correlated factors and minimize the number of indicators (i.e., food groups) that have high loading on one factor[160,161] The first factor extracted is the one that accounts for the greatest variance in the dataset. The second factor, independent of the first, explains the largest possible share of the remaining variance and so on, without the components being correlated with each other. Three selection criteria were used to determine which factors

should be retained and later included in regression models: 1) factors with an eigenvalue greater than one, 2) interpretation of the scree plot (Figure 3.1), and 3) the interpretable variance percentage.[159] The principal components, or factors, are unique dietary profiles that are named primarily based on the food groups that loaded highly within each factor (Table 3.2). I then calculated demographic and dietary characteristics for participants across tertiles of each dietary pattern. I tested for differences across tertiles using a Chi-Square tests for categorical variables and adjusted Wald Tests for continuous variables (Tables 3.3-3.7).

Once I selected which factors to retain, I computed predicted scores of every retained factor for each respondent using the *predict* command in Stata. These scores were subsequently utilized for both data exploration and prediction models.[162] These predicted factor scores were derived by multiplying each food group's factor loading by a respondent's corresponding food group value (scoring coefficient) and then summing across food groups to determine the participant's factor score for each dietary profile. I then standardized these predicted scores (mean scaled to 0, standard deviation scaled to 1) in order to make the results comparable across all retained dietary profiles. These standardized predicted dietary profile scores became the dependent variables in subsequent regression analyses.

**Independent Variable**

*Food security status* was measured by the validated USDA's 18-item household food security module in the NHANES. Three categories were assigned according to the USDA guidelines: high/marginal food security (reference category), low food security, and very low food security. The level of food security was determined by the number of affirmative

responses to the 18-item questionnaire module as well as household composition. An example of one of the questions is "[In the last 12 months], were you ever hungry but didn't eat because there wasn't enough money for food?" Respondents who provided no affirmative responses to any of the items were considered fully food secure. Respondents who provided 1-2 affirmative responses were considered marginally food secure. Those who provide 3-5 affirmative for a household without children under the age of 18 or 3-7 affirmative responses for a household with children were considered to have low food security. Those who provide 6-10 affirmative responses for a household without children under the age of 18 or 8-18 affirmative responses for a household with children were considered to have very low food security.

**Covariates**

*Covariates* included: age (years); sex (male, female); education level (less than high school diploma, high school diploma or equivalent, some college or technical training, university graduate or greater); income ($0-19,999, $20,000-34,999, $35,000+); and nativity and duration of residence in the United States (born in the United States, foreign-born and living in the United States for less than 10 years, foreign-born and living the United States for 10 years or more).

**Multivariable Regression**

I used the standardized predicted scores as the outcome variables in regression models in order to examine the association between food security status and dietary profiles. While my aforementioned selection criteria identified 11 unique factors, I only retained five different dietary profiles as outcomes in the regression models, as the first five factors explained the most variance and had the most interpretable dietary profiles. I

regressed food security status on the predicted scores for each of the five unique dietary profiles using Ordinary Least Squares (OLS). I included covariates such as age, sex, education, income, and nativity and duration of residence in the United States in all regression models. I conducted sensitivity analyses by including additional covariates such as household size and family make-up, but the inclusion of these variables did not impact the original models and thus were excluded from the final models. The USDA 18-item food security module which was used to measure food security status is inclusive of whether there are children present in the home which controls for whether or not children are in the home. All statistical analyses were conducted using Stata 16 IC.[163]

## RESULTS

### Sample Characteristics

The overall analytical sample was 51.7% female and 48.3% male and had an average age of 40.2 years (Table 3.1). In addition, the majority of the analytical sample of Latinos identified as Mexican American (62.3%) compared to Other Hispanic (37.7%). Among the Latinos who reported very low food security, a large proportion had household income levels less than $20,000 (43.1%) and less than a high school diploma (50.9%).

### Dietary Profiles

There was sufficient correlation between different foods to proceed with factor analysis based on the value of the KMO test (0.66). The Bartlett test of sphericity was highly significant ($p < 0.001$), indicating homogeneity of variance by the consumption of foods. Eleven components, or factors, were extracted by factor analysis for different food groups using the criteria stated above. The 11 factors had an eigenvalue over 1, accounting for about 59.4% of the total observed variation in the food-consumption patterns among

Latinos (Table 3.2). Only food groups with absolute value loadings greater than or equal to 0.40[164] were retained and considered significant contributors to each to each factor (Table 3.2).

The rest of the results focus on the first five factors, since these factors were the only ones included in regression models. These five factors accounted for 36.2% of the total observed variation in the food-consumption patterns among Latinos. The first factor, which accounted for 11.8% of the total variance, was labeled as the *Solid Fats, Cheese, & Refined Carbs* dietary profile, as high factor loadings (0.40 or greater) were observed for solid fats, refined grains, cheese, added sugars, and tomatoes and tomato products. The second factor, which accounted for 8.4% of the total variance, was labeled as the *Beans and Legumes* dietary profile, as high factor loadings were observed for beans and peas (legumes). The third factor, which accounted for 6.7% of the total variance, was labeled as the *Plant-based* dietary profile, as high factor loadings were observed for peanuts, nuts, seeds, soy, and fruits (other). The fourth factor, which accounted for 4.8% of the total variance, was labeled as the *Vegetables* dietary profile, as high factor loadings were observed for other vegetables, total red and orange vegetables, tomatoes and tomato products. The fifth factor, which accounted for 4.5% of the total variance, was labeled as the *Alcohol and Carbohydrates* dietary profile, as high factor loadings were observed for potatoes, alcohol, and added sugars.

I examined the sample characteristics for each of the five dietary profiles and found significant differences across tertiles of each dietary profile score by specific demographic, socioeconomic, and dietary variables (Tables 3.3-3.7). For the *Solid Fats, Cheese, & Refined Carbs* dietary profile (Table 3.3), there were significant differences by age. The average age

of respondents in the lowest tertile was older (43.4 years) compared to those in the highest tertile (37.6 years). In the lowest tertile, less than a third were male (31.3%). This contrasts to the highest tertile where 61.5% were male. Mexican-Americans made up 67.8% of the highest tertile, compared to 54.2% in the lowest tertile. There were no significant differences by food security status, education level, or nativity and duration of residence across the tertiles.

For the *Beans and Legumes* dietary profile (Table 3.4), there were significant differences in the tertiles by age such that older people were in the highest tertile. In the lowest tertile, 60.3% of respondents were born in the United States, whereas in the highest tertile, 37.% of respondents were born in the United States. There were also significant differences by level of education. In the highest tertile, there was 41.9% of respondents with less than a high school diploma, whereas in the lowest tertile, there was only 28.6% of respondents. Additionally, in the lowest tertile, over 60% of respondents were born in the United States compared to only 37.8% in the highest tertile. There were no differences by food security status, income, or race/Hispanic origin across the tertiles.

For the *Plant-Based* dietary profile (Table 3.5), the only significant difference in tertiles was by education level, whereas in the highest tertile, 52.5% of respondents had some level of higher education, whereas, in the lowest tertile, 41.3% of respondents had some level of higher education.

For the *Vegetables* dietary profile (Table 3.6) there were significant differences in the tertile by both food security status and income. In the highest tertile, those with very low food security made up 6.9% of respondents, whereas in the lowest tertile, those with very low food security made up 12.6% of respondents. In the highest tertile, 13.6% of

respondents had household incomes less than $20,000, whereas, in the lowest tertile, 28.5% of respondents had household incomes less than $20,000. Additionally, in the lowest tertile, 54.9% of respondents were born in the United States compared to only 39.2% in the highest tertile. There were no significant differences by sex or education level across the tertiles.

For the *Alcohol and Carbohydrates* (Table 3.7) dietary profile, in the lowest tertile, 59% were female. This contrasts to the highest tertile where 42.4% were female. Additionally, in the lowest tertile, over 39.1% of respondents were born in the United States compared to 59.1% in the highest tertile. There were no differences by food security status, income, education level, or race/Hispanic origin across the tertiles.

**Multivariable Regression Results**

*Solid Fats, Cheese, & Refined Carbs Dietary Profile*

There were no significant differences in the means for the *Solid Fats, Cheese, & Refined Carbs* dietary profile scores between the food insecurity groups compared to the reference group (food secure) (Model 1, Table 3.8). The low food security group had a 0.05 higher standardized score compared to the reference group, but this was not significant. Being male (β=0.55; 95% CI:0.36, 0.74) was significantly associated with higher scores (the reference group is female) for this dietary profile. In addition, having a high school diploma (β= -0.19; 95% CI:-0.30,-0.02) was significantly associated with lower scores (reference group is less than a high school diploma) for this dietary profile.

*Beans and Legumes Dietary Profile*

There were no significant differences in the means between the food insecurity groups compared to the reference groups (food secure) for the *Beans and Legumes* dietary

profile (Model 2, Table 3.8). The low food security group had a 0.08 higher standardized score, and the very low food security group had a 0.9 higher standardized score compared to the reference group, but these differences were not significant. Being male (β=0.27; 95% CI:0.06, 0.49) was significantly associated with higher scores (the reference group is female) for this dietary profile. In addition, being foreign-born and living in the United States for less than 10 years (β=0.47; 95% CI:0.17, 0.77) was significantly associated with higher scores (reference group is born in the United States) for this dietary profile.

*Plant-Based Dietary Profile*

There was a significant difference in the means between the very low food security compared to the reference groups (food secure) for the *Plant-Based* dietary profile (Model 3, Table 3.8) (β= -0.18; 95% CI:-0.35, 0.03). The low food security group had a -0.13 lower standardized score compared to the reference group, but this was not significant. Having some college education or more (β= 0.44; 95% CI:0.02, 0.85) was significantly associated with higher scores (reference group is less than a high school diploma) for this dietary profile.

*Vegetables Dietary Profile*

There was a significant difference in the means between both the low food security group and the very low food security group compared to the reference group (food secure) for the *Vegetables* dietary profile (Model 4, Table 3.8). The low food security group had a -0.18 (95% CI:-0.36, -0.01) lower standardized score, and the very low food security group had a -0.27 (95% CI:-0.44, -0.10) lower standardized score, compared to the reference group. Having a household income of $35,000 or more (β= 0.35; 95% CI:0.18, 0.53) was significantly associated with higher scores (reference group is less than $20,000) for this

dietary profile. In addition, being foreign-born and living in the United States for 10 years or more (β= 0.37; 95% CI:0.19, 0.56) was significantly associated with higher scores (reference group is born in the United States) for this dietary profile.

*Alcohol and Carbohydrates Dietary Profile*

There was a statistically significant difference in the means between the very low food security compared to the reference groups (food secure) for the *Alcohol and Carbohydrates* dietary profile (β= -0.32; 95% CI:-0.61, -0.03) (Model 5, Table 3.8). The low food security group had a -0.10 lower standardized score compared to the reference group, but this was not significant. Being male was significantly associated (β=0.37; 95% CI:0.20, -0.53) with higher scores (the reference group is female) for this dietary profile. In addition, being foreign-born and living in the United States for 10 years or more (β= -0.40; 95% CI:-0.34, 0.18) was significantly associated with lower scores (reference group is born in the United States) for this dietary profile.

## DISCUSSION

In this chapter, I identified dietary profiles among Latinos in the United States and determined that some, but not all, differed by level of food insecurity. I was motivated by previous research that has not found differences in diet quality by food security status among Latinos. I identified a total of 11 different dietary profiles, with five of them making up the majority of the total variance and proportion: *Solid Fats, Cheese, & Refined Carbs, Beans and Legumes, Plant-based, Vegetables, Alcohol and Carbohydrates* dietary profiles. In contrast to previous research, I found differences in the five dietary profiles by food security status, but not always in the expected directions. I found that Latinos who are food

insecure are no more likely to eat low-quality, caloric-dense foods (e.g. *Solid Fats, Cheese, & Refined Carbs* profile) compared to those who are food secure. Instead, the findings from the regression models indicate that Latinos experiencing food insecurity are less likely to eat high-quality protective foods (e.g. *Plant-based* and *Vegetables* profiles) compared to those who are food secure. Previous studies and theoretical frameworks presented throughout the food insecurity literature, such as the energy-density cost framework, have proposed that individuals experiencing food insecurity are more likely to select energy-dense and hyperpalatable foods as a deliberate strategy to save money and increase energy intake.[144,145] My findings do not support this framework, however. Instead, Latinos experiencing the highest level of food insecurity were less likely to consume diets high in vegetables, plant-based foods, and *alcohol and carbohydrates (*potatoes and added sugar) compared to their food-secure counterparts. In other words, food-insecure Latinos are less likely to consume both diets with high foods (vegetables, fruits, nuts, etc) and low-quality foods (alcohol), but not more likely to consume hyperpalatable diets compared to their food-secure counterparts as proposed previously in the food insecurity literature.

**Limitations**

The NHANES contains cross-sectional data that cannot be used to determine causality or the directionality of the models. Additionally, some measures such as dietary intake are self-reported and thus are at risk of recall and social desirability biases.[43] Household food insecurity is assessed over the past 12 months, whereas dietary intake is assessed at the time of the survey. This may result in misclassification of dietary patterns at the time of experiencing food insecurity, as food insecurity can be a transient or cyclical[68] condition and can vary over time.[69–71] Another limitation of this study is the reduced

sample size by excluding respondents who only had one day of dietary data. The analytical sample in this study had two days of dietary data and thus might consist of a different make-up of participants who only had 1 day. Post-hoc tests should examine potential differences in the results and sample descriptives when including respondents with only one day of dietary data. The last limitation is the possible double counting of dietary intake of beans and legumes. The USDA has two separate food group equivalents for beans and legumes, computed as proteins and vegetables. In this study, both groups were included.

**Future Directions and Conclusions**

To my knowledge, this study is the first to utilize data-driven exploratory factor analysis to determine dietary profiles of Latinos in the United States and determine their associations with food security status. My findings suggest that Latinos experiencing food insecurity are less likely to consume diets high in vegetables and plant-based foods compared to their food-secure counterparts, but not more likely to consume diets high in hyperpalatable foods (*Solid Fats, Cheese, & Refined Carbohydrates* profile). Future observational studies could use more rigorous study designs such as retrospective or prospective cohorts. Additionally, Latinos are a highly heterogeneous population and future studies using robust dietary assessment should examine dietary profiles among Latino and Hispanic subgroups.

Future studies examining the relationship between food security status and diet quality among racial and ethnic minorities should consider the limitations of commonly used measures of diet quality such as the Healthy Eating Index (HEI) and when possible use alternative measures of diet quality. The HEI has been found to be a reliable and valid measure of diet quality among the general United States population. However, certain

components of the HEI such as dairy intake, inadvertently discriminate against Latinos' and non-Hispanic Black' scores for the HEI. This is because Latinos and non-Hispanic Blacks have lower rates of lactose persistence than non-Hispanic whites.[151,152]

These findings may inform policy and interventions to increase healthy diets and decrease food insecurity. Future efforts to increase the intake of vegetables and fruits, specifically among food insecure populations should not just focus on individual dietary change, but instead encompass community-focused and macro-level interventions that address food insecurity and the local food environment by increasing accessibility and affordability to fresh fruits and vegetables. The Supplemental Nutrition Assistance Program (SNAP), which acts as the primary safety net for food-insecure families has been an effective program for countering food insecurity, including Latinos.[165] However, not all Latinos qualify for SNAP due to eligibility criteria that exclude non-citizens. Additionally, Latinos have some of the lowest participation rates in SNAP.[166,167] One factor related to this is that immigrant and "mixed-status" families may be deterred to apply for federal benefits on behalf of their children due to unclear eligibility guidelines and processes and concern about exposing their immigration status to the government. Future interventions should consider these barriers and assist with linkage to non-federal programs, such as local and community resources (such as food pantries), if families are not eligible for federal public benefits.

Food pantries and food banks in communities are valuable to those who experience food insecurity including Latinos[168]. Findings from a nationwide assessment of pantries have revealed a high demand for fresh vegetables and fruits among clients.[169] Although qualitative findings indicate that increased access to fresh produce in food pantries does

not necessarily lead to increased consumption of produce among food pantry clients, this could be due to the poor quality of produce, irregularity, shorter shelf life, and the lack of cooking skills to prepare certain types of fresh produce.[170] These factors should be considered when offering fresh produce at food banks and food pantries.

Finally, states and local policies can promote positive dietary consumption including increased intake of fresh vegetables and fruit through SNAP and other programs by offering reimbursement and acceptance at local farmers' markets.[171–174]

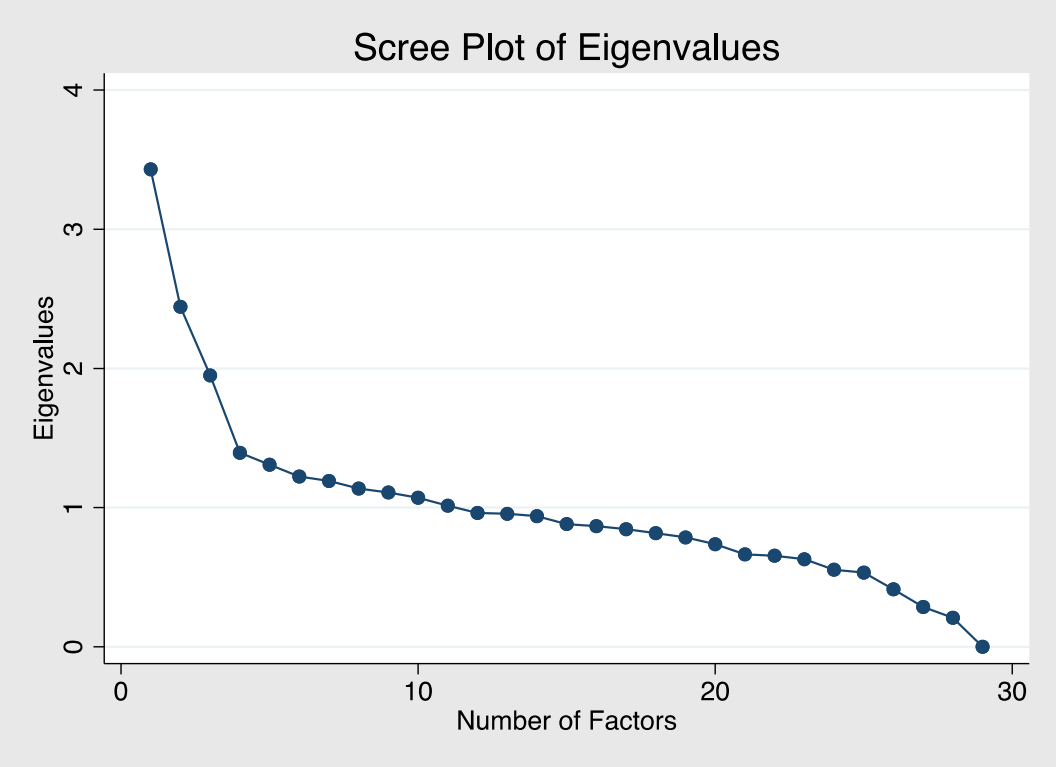

Figure 3.1: Screeplot of Eigenvalues

Table 3.1: Weighted Sample Description by Food Security Status, Latino Adult Respondents, National Health and Nutrition Examination Survey, 2013-2018 (n=2,049)

| | High/ Marginal Food Security (n=1,398) | Low Food Security (n=442) | Very Low Food Security (n=209) | ALL (n=2,049) |
|---|---|---|---|---|
| **Demographics** | | | | |
| Mean Age | 40.6 | 38.7 | 40.1 | 40.2 |
| Sex, % | | | | |
| Female | 50.4 | 55.0 | 54.8 | 51.7 |
| Male | 49.6 | 45.1 | 45.1 | 48.3 |
| Race/Hispanic Origin, % | | | | |
| Other Hispanic | 38.3 | 36.4 | 36.5 | 37.7 |
| Mexican American | 61.7 | 63.6 | 63.5 | 62.3 |
| Nativity & Duration of Residence in the US, % | | | | |
| Born in the US | 50.7 | 46.4 | 43.1 | 49.1 |
| Living in the US <10 Years | 9.6 | 10.6 | 18.1 | 10.6 |
| Living in the US 10 Years or more | 39.7 | 43.0 | 38.8 | 40.3 |
| **Socioeconomic Status** | | | | |
| Household Annual Income, % | | | | |
| $0-19,999 | 14.3 | 32.9 | 43.0 | 20.8 |
| $20,000-34,999 | 17.2 | 33.5 | 25.5 | 21.4 |
| $35,000+ | 68.6 | 33.7 | 31.5 | 57.8 |
| Education Level, % | | | | |
| Less than High School | 29.6 | 44.2 | 50.9 | 34.6 |
| High School Diploma | 21.4 | 22.1 | 25.5 | 21.9 |
| Some College+ | 49.0 | 33.7 | 23.7 | 43.4 |
| **Food Security Status** | | | | |
| High/Marginal Food Security, % | -- | -- | -- | 69.7 |
| Low Food Security, % | -- | -- | -- | 21.3 |
| Very Low Food Security, % | -- | -- | -- | 9.0 |

Table 3.2: Factor Loadings for Dietary Profiles, Latino Adult Respondents, National Health and Nutrition Examination Survey, 2013-2018 (n=2,049)

| Food Groups (n=29) | Factor1 | Factor2 | Factor3 | Factor4 | Factor5 |
|---|---|---|---|---|---|
| | *Solid Fats, Cheese, & Refined Carbs* | *Beans and Legumes* | *Plant-Based* | *Vegetables* | *Alcohol & Carbohydrates* |
| **Solid Fats** | **0.84** | 0.05 | 0.03 | 0.01 | 0.19 |
| **Refined Grains** | **0.81** | 0.19 | -0.03 | 0.04 | -0.02 |
| **Cheeses** | **0.78** | 0.08 | -0.02 | 0.11 | -0.11 |
| **Added Sugars** | **0.52** | -0.03 | 0.02 | -0.22 | **0.44** |
| **Beans and Peas Computed as Proteins** | 0.08 | **0.99** | 0.00 | 0.02 | 0.00 |
| **Beans and Peas Computed as Vegetables** | 0.08 | **0.99** | 0.00 | 0.02 | 0.00 |
| **Nuts and Seeds** | 0.01 | 0.03 | **0.72** | 0.04 | 0.08 |
| **Soy Products** | -0.01 | -0.07 | **0.71** | 0.01 | -0.06 |
| **Whole Fruits (exclud. Melons, Citrus, Berries)** | -0.09 | 0.04 | **0.48** | 0.30 | -0.18 |
| **Oils** | 0.37 | 0.15 | 0.38 | 0.21 | 0.38 |
| **Vegetables, Other (Not Already Listed)** | 0.18 | 0.11 | 0.03 | **0.74** | 0.01 |
| **Red and Orange Vegetables (exlclud. Tomatoes/Tomato Products)** | -0.11 | -0.06 | 0.32 | **0.56** | 0.01 |
| **Tomatoes and Tomato Products** | **0.48** | -0.01 | -0.14 | **0.49** | -0.08 |
| **Whole Fruits (Melons, Citrus, Berries only)** | -0.05 | 0.08 | 0.06 | 0.34 | -0.09 |
| **White Potatoes** | 0.03 | -0.02 | 0.01 | -0.06 | **0.74** |
| **Alcohol** | 0.02 | 0.05 | -0.11 | 0.10 | **0.45** |
| **Fruit Juice** | 0.00 | -0.02 | -0.21 | 0.09 | 0.08 |
| **Whole Grains** | -0.14 | 0.01 | 0.17 | 0.18 | 0.07 |
| **Yogurts** | -0.07 | -0.04 | 0.21 | -0.01 | 0.00 |
| **Eggs** | 0.18 | 0.02 | 0.04 | 0.07 | 0.04 |
| **Cured Meats** | 0.16 | -0.08 | 0.00 | -0.15 | 0.03 |
| **Seafood Low in Omega-3 Fatty Acids** | -0.05 | -0.02 | 0.08 | 0.06 | 0.00 |
| **Seafood High in Omega-3 Fatty Acids** | -0.04 | -0.04 | 0.04 | 0.00 | -0.02 |
| **Poultry** | -0.01 | 0.03 | -0.02 | 0.14 | 0.09 |
| **Beef, Veal, Pork, Lamb, and Game Meat** | 0.21 | 0.00 | -0.07 | 0.19 | 0.43 |
| **Other Starchy Vegetables (exclud. White Potatoes)** | -0.07 | 0.07 | 0.16 | 0.21 | 0.13 |
| **Dark Green Vegetables** | -0.13 | -0.04 | 0.13 | 0.36 | -0.02 |
| **Organ Meat** | -0.02 | -0.02 | -0.07 | 0.03 | 0.02 |
| **Milk** | 0.31 | 0.06 | 0.16 | -0.15 | -0.02 |
| **Dietary Variance Explained, %** | 11.83 | 8.42 | 6.72 | 4.81 | 4.51 |
| **Eigenvalue** | 3.43 | 2.44 | 1.95 | 1.39 | 1.31 |

Table 3.3: Sample Characteristics of the Solid Fats, Cheese, & Refined Carbohydrates Dietary Profile, Latino Adult Respondents, National Health and Nutrition Examination Survey, 2013-2018 (n=2,049)

| **Characteristics** | | **Tertiles** | | | |
|---|---|---|---|---|---|
| | **Overall** | **T1** | **T2** | **T3** | |
| **N** | 2049 | 683 | 683 | 683 | |
| **Food Security Status, %** | | | | | |
| Full/Marginal Food Security | 69.7 | 68.9 | 69.4 | 70.7 | |
| Low Food Security | 21.3 | 22.7 | 21.2 | 20.2 | |
| Very Low Food Security | 9.0 | 8.4 | 9.4 | 9.1 | |
| **Age, Mean (In Years)** | 40.2 | 43.4 | 40.2 | 37.6 | *** |
| **Sex, %** | | | | | |
| Female | 51.7 | 68.7 | 51.7 | 38.6 | *** |
| Male | 48.3 | 31.3 | 48.3 | 61.5 | *** |
| **Household Annual Income, %** | | | | | |
| $0-19,999 | 20.8 | 21.6 | 22.3 | 18.8 | ** |
| $20,000-34,999 | 21.4 | 27.2 | 18.7 | 19.5 | ** |
| $35,000+ | 57.8 | 51.2 | 59.0 | 61.8 | ** |
| **Education Level, %** | | | | | |
| Less than High School | 34.6 | 38.7 | *29.4* | 36.6 | |
| High School Diploma | 21.9 | 20.6 | 23.4 | 21.5 | |
| Some College+ | 43.4 | 40.7 | 47.2 | 41.9 | |
| **Nativity & Duration of Residence, %** | | | | | |
| US Born | 49.1 | 44.1 | 51.0 | 51.3 | |
| Living In the US <10 Years | 10.6 | 11.4 | 8.9 | 11.5 | |
| Living in the US 10 Years+ | 40.3 | 44.5 | 40.1 | 37.2 | |
| **Race/Hispanic Origin, %** | | | | | |
| Other Hispanic | 37.7 | 45.8 | 36.9 | 32.2 | *** |
| Mexican American | 62.3 | 54.2 | 63.1 | 67.8 | *** |
| **Dietary Intake** | | | | | |
| Total Energy, Mean (kcal/day) | 2082 | 1500 | 1940 | 2689 | *** |
| Protein (% of energy) | 16.7 | 18.7 | 16.2 | 15.6 | *** |
| Fat (% of energy) | 33.5 | 30.6 | 33.7 | 35.7 | *** |
| Carbohydrates (% of energy) | 49.1 | 49.8 | 49.3 | 48.2 | |
| Saturated Fat (grams/1000kcal) | 12.0 | 10.0 | 11.8 | 13.8 | *** |
| Cholesterol (mg/1000kcal) | 153.7 | 164.0 | 152.1 | 147.0 | |
| Fiber (grams/1000kcal) | 9.4 | 11.2 | 9.2 | 8.3 | *** |
| Sodium (mg/1000kcal) | 1682.5 | 1711.2 | 1632.7 | 1709.2 | ** |
| Fruit Intake (cup equiv.) | 1.1 | 1.3 | 1.1 | 0.9 | |
| Vegetable (cup equiv.) | 1.5 | 1.4 | 1.3 | 1.6 | |
| Red Meat^ (oz equiv.) | 1.9 | 1.5 | 1.5 | 2.5 | |
| Added Sugar (tsp equiv.) | 16.0 | 8.4 | 15.1 | 22.9 | *** |

Tests of Significance = *** p<0.01, ** p<0.05, * p<0.1
Chi-Square Test for Categorical Variables, Adjusted Wald Test for Continuous Variables
^excludes organ and cured meats

Table 3.4: Sample Characteristics of the Beans and Legumes Dietary Profile, Latino Adult Respondents, National Health and Nutrition Examination Survey, 2013-2018 (n=2,049)

| **Characteristics** | | **Tertiles** | | | |
|---|---|---|---|---|---|
| | **Overall** | **T1** | **T2** | **T3** | |
| **N** | 2049 | 683 | 683 | 683 | |
| **Food Security Status, %** | | | | | |
| Full/Marginal Food Security | 69.7 | 72.1 | 68.3 | 68.4 | |
| Low Food Security | 21.3 | 20.7 | 21.8 | 21.4 | |
| Very Low Food Security | 9.0 | 7.2 | 9.8 | 10.1 | |
| **Age, Mean (In Years)** | 40.2 | 37.8 | 42.1 | 40.9 | *** |
| **Sex, %** | | | | | |
| Female | 51.7 | 49.3 | 58.9 | 47.7 | ** |
| Male | 48.3 | 50.7 | 41.1 | 52.3 | ** |
| **Household Annual Income, %** | | | | | |
| $0-19,999 | 20.8 | 20.5 | 20.9 | 21.1 | |
| $20,000-34,999 | 21.4 | 19.9 | 20.9 | 23.4 | |
| $35,000+ | 57.8 | 59.6 | 58.2 | 55.5 | |
| **Education Level, %** | | | | | |
| Less than High School | 34.6 | 28.6 | 33.9 | 41.9 | ** |
| High School Diploma | 21.9 | 23.2 | 24.0 | 18.6 | ** |
| Some College+ | 43.4 | 48.2 | 42.1 | 39.5 | ** |
| **Nativity & Duration of Residence, %** | | | | | |
| US Born | 49.1 | 60.3 | 48.4 | 37.8 | *** |
| Living In the US <10 Years | 10.6 | 7.8 | 9.7 | 14.4 | *** |
| Living in the US 10 Years+ | 40.3 | 31.9 | 41.9 | 47.9 | *** |
| **Race/Hispanic Origin, %** | | | | | |
| Other Hispanic | 37.7 | 37.8 | 39.7 | 35.8 | |
| Mexican American | 62.3 | 62.2 | 60.3 | 64.2 | |
| **Dietary Intake** | | | | | |
| Total Energy, Mean (kcal/day) | 2082 | 2123 | 1806 | 2300 | *** |
| Protein (% of energy) | 16.7 | 16.7 | 16.9 | 16.6 | |
| Fat (% of energy) | 33.5 | 34.8 | 33.2 | 32.4 | *** |
| Carbohydrates (% of energy) | 49.1 | 48.5 | 48.7 | 50.0 | |
| Saturated Fat (grams/1000kcal) | 12.0 | 12.9 | 11.5 | 11.5 | *** |
| Cholesterol (mg/1000kcal) | 153.7 | 160.2 | 157.6 | 142.9 | |
| Fiber (grams/1000kcal) | 9.4 | 7.7 | 9.0 | 11.7 | *** |
| Sodium (mg/1000kcal) | 1682.5 | 1749.8 | 1657.6 | 1633.2 | ** |
| Fruit Intake (cup equiv.) | 1.1 | 1.1 | 1.0 | 1.1 | |
| Vegetable (cup equiv.) | 1.5 | 1.6 | 1.3 | 1.5 | *** |
| Red Meat^ (oz equiv.) | 1.9 | 1.9 | 1.7 | 1.9 | |
| Added Sugar (tsp equiv.) | 16.0 | 18.6 | 13.4 | 15.7 | *** |

Tests of Significance = *** p<0.01, ** p<0.05, * p<0.1
Chi-Square Test for Categorical Variables, Adjusted Wald Test for Continuous Variables
^excludes organ and cured meats

Table 3.5: Sample Characteristics of the Plant-Based Dietary Profile, Latino Adult Respondents, National Health and Nutrition Examination Survey, 2013-2018 (n=2,049)

| **Characteristics** | | **Tertiles** | | | |
|---|---|---|---|---|---|
| | **Overall** | **T1** | **T2** | **T3** | |
| **N** | 2049 | 683 | 683 | 683 | |
| **Food Security Status, %** | | | | | |
| Full/Marginal Food Security | 69.7 | 67.3 | 66.0 | 75.7 | |
| Low Food Security | 21.3 | 22.3 | 24.4 | 17.3 | |
| Very Low Food Security | 9.0 | 10.4 | 9.6 | 7.1 | |
| ***Age, Mean (In Years)*** | 40.2 | 40.1 | 39.9 | 40.5 | |
| **Sex, %** | | | | | |
| Female | 51.7 | 47.9 | 54.3 | 53.3 | * |
| Male | 48.3 | 52.1 | 45.7 | 46.7 | * |
| **Household Annual Income, %** | | | | | |
| $0-19,999 | 20.8 | 21.8 | 22.1 | 18.6 | |
| $20,000-34,999 | 21.4 | 22.6 | 22.9 | 18.7 | |
| $35,000+ | 57.8 | 55.6 | 55.0 | 62.7 | |
| **Education Level, %** | | | | | |
| Less than High School | 34.6 | 36.4 | 39.4 | 28.4 | *** |
| High School Diploma | 21.9 | 22.3 | 24.6 | 19.1 | *** |
| Some College+ | 43.4 | 41.3 | 36.0 | 52.5 | *** |
| **Nativity & Duration of Residence, %** | | | | | |
| US Born | 49.1 | 50.8 | 48.4 | 48.1 | |
| Living In the US <10 Years | 10.6 | 11.1 | 11.7 | 9.0 | |
| Living in the US 10 Years+ | 40.3 | 38.1 | 39.9 | 42.9 | |
| **Race/Hispanic Origin, %** | | | | | |
| Other Hispanic | 37.7 | 37.6 | 35.8 | 39.6 | |
| Mexican American | 62.3 | 62.4 | 64.2 | 60.4 | |
| **Dietary Intake** | | | | | |
| Total Energy, Mean (kcal/day) | 2082 | 1976 | 1979 | 2287 | |
| Protein (% of energy) | 16.7 | 17.2 | 16.2 | 16.8 | *** |
| Fat (% of energy) | 33.5 | 31.2 | 34.1 | 34.6 | *** |
| Carbohydrates (% of energy) | 49.1 | 48.6 | 49.6 | 48.9 | |
| Saturated Fat (grams/1000kcal) | 12.0 | 11.7 | 12.4 | 11.9 | ** |
| Cholesterol (mg/1000kcal) | 153.7 | 169.1 | 159.3 | 132.7 | * |
| Fiber (grams/1000kcal) | 9.4 | 8.8 | 8.6 | 10.8 | |
| Sodium (mg/1000kcal) | 1682.5 | 1768.9 | 1690.3 | 1587.3 | ** |
| Fruit Intake (cup equiv.) | 1.1 | 0.9 | 0.8 | 1.6 | ** |
| Vegetable (cup equiv.) | 1.5 | 1.4 | 1.3 | 1.7 | ** |
| Red Meat^ (oz equiv.) | 1.9 | 2.1 | 1.8 | 1.7 | * |
| Added Sugar (tsp equiv.) | 16.0 | 15.3 | 16.7 | 16.1 | |

Tests of Significance = *** p<0.01, ** p<0.05, * p<0.1
Chi-Square Test for Categorical Variables, Adjusted Wald Test for Continuous Variables
^excludes organ and cured meats

Table 3.6: Sample Characteristics of the Vegetables Dietary Profile, Latino Adult Respondents, National Health and Nutrition Examination Survey, 2013-2018 (n=2,049)

| **Characteristics** | | **Tertiles** | | | |
|---|---|---|---|---|---|
| | **Overall** | **T1** | **T2** | **T3** | |
| **N** | 2049 | 683 | 683 | 683 | |
| **Food Security Status, %** | | | | | |
| Full/Marginal Food Security | 69.7 | 61.8 | 72.2 | 75.0 | *** |
| Low Food Security | 21.3 | 25.6 | 20.2 | 18.1 | *** |
| Very Low Food Security | 9.0 | 12.6 | 7.6 | 6.9 | *** |
| ***Age, Mean (In Years)*** | 40.2 | 37.9 | 40.8 | 41.7 | *** |
| **Sex, %** | | | | | |
| Female | 51.7 | 51.8 | 55.7 | 47.7 | |
| Male | 48.3 | 48.2 | 44.3 | 52.3 | |
| **Household Annual Income, %** | | | | | |
| $0-19,999 | 20.8 | 28.5 | 20.5 | 13.6 | *** |
| $20,000-34,999 | 21.4 | 23.5 | 16.2 | 24.5 | *** |
| $35,000+ | 57.8 | 48.0 | 63.2 | 61.8 | *** |
| **Education Level, %** | | | | | |
| Less than High School | 34.6 | 37.2 | 32.0 | 34.8 | |
| High School Diploma | 21.9 | 22.7 | 21.9 | 21.2 | |
| Some College+ | 43.4 | 40.1 | 46.1 | 44.1 | |
| **Nativity & Duration of Residence, %** | | | | | |
| US Born | 49.1 | 54.9 | 53.4 | 39.2 | *** |
| Living In the US <10 Years | 10.6 | 12.3 | 8.7 | 10.7 | *** |
| Living in the US 10 Years+ | 40.3 | 32.8 | 37.9 | 50.1 | *** |
| **Race/Hispanic Origin, %** | | | | | |
| Other Hispanic | 37.7 | 43.2 | 33.7 | 36.5 | ** |
| Mexican American | 62.3 | 56.8 | 66.3 | 63.5 | ** |
| **Dietary Intake** | | | | | |
| Total Energy, Mean (kcal/day) | 2082 | 1984 | 1989 | 2273 | |
| Protein (% of energy) | 16.7 | 15.7 | 16.8 | 17.6 | *** |
| Fat (% of energy) | 33.5 | 33.2 | 33.7 | 33.5 | |
| Carbohydrates (% of energy) | 49.1 | 51.2 | 48.7 | 47.3 | *** |
| Saturated Fat (grams/1000kcal) | 12.0 | 12.2 | 12.1 | 11.7 | |
| Cholesterol (mg/1000kcal) | 153.7 | 148.4 | 157.7 | 154.9 | |
| Fiber (grams/1000kcal) | 9.4 | 7.9 | 9.2 | 11.2 | *** |
| Sodium (mg/1000kcal) | 1682.5 | 1598.5 | 1696.9 | 1750.5 | *** |
| Fruit Intake (cup equiv.) | 1.1 | 0.8 | 1.0 | 1.5 | *** |
| Vegetable (cup equiv.) | 1.5 | 0.8 | 1.2 | 2.3 | *** |
| Red Meat^ (oz equiv.) | 1.9 | 1.4 | 1.8 | 2..4 | ** |
| Added Sugar (tsp equiv.) | 16.0 | 19.7 | 14.9 | 13.6 | *** |

Tests of Significance = *** p<0.01, ** p<0.05, * p<0.1
Chi-Square Test for Categorical Variables, Adjusted Wald Test for Continuous Variables
^excludes organ and cured meats

Table 3.7: Sample Characteristics of the Alcohol and Carbohydrates Dietary Profile, Latino Adult Respondents, National Health and Nutrition Examination Survey, 2013-2018 (n=2,049)

| **Characteristics** | | **Tertiles** | | | |
|---|---|---|---|---|---|
| | **Overall** | **T1** | **T2** | **T3** | |
| **N** | 2049 | 683 | 683 | 683 | |
| **Food Security Status, %** | | | | | |
| Full/Marginal Food Security | 69.7 | 66.7 | 68.0 | 73.9 | |
| Low Food Security | 21.3 | 21.0 | 22.9 | 20.2 | |
| Very Low Food Security | 9.0 | 12.3 | 9.1 | 5.9 | |
| ***Age, Mean (In Years)*** | 40.2 | 40.8 | 40.7 | 39.1 | |
| **Sex, %** | | | | | |
| Female | 51.7 | 59.0 | 55.0 | 42.4 | *** |
| Male | 48.3 | 41.0 | 45.0 | 57.6 | *** |
| **Household Annual Income, %** | | | | | |
| $0-19,999 | 20.8 | 22.8 | 18.8 | 20.9 | |
| $20,000-34,999 | 21.4 | 23.9 | 19.0 | 21.3 | |
| $35,000+ | 57.8 | 53.3 | 62.2 | 56.8 | |
| **Education Level, %** | | | | | |
| Less than High School | 34.6 | 39.4 | 34.8 | 30.3 | |
| High School Diploma | 21.9 | 21.5 | 21.5 | 22.7 | |
| Some College+ | 43.4 | 39.1 | 43.7 | 47 | |
| **Nativity & Duration of Residence, %** | | | | | |
| US Born | 49.1 | 39.1 | 48.0 | 59.1 | *** |
| Living In the US <10 Years | 10.6 | 12.8 | 10.4 | 8.7 | *** |
| Living in the US 10 Years+ | 40.3 | 48.2 | 41.6 | 32.2 | *** |
| **Race/Hispanic Origin, %** | | | | | |
| Other Hispanic | 37.7 | 37.6 | 34.8 | 40.5 | |
| Mexican American | 62.3 | 62.4 | 65.2 | 59.5 | |
| **Dietary Intake** | | | | | |
| Total Energy, Mean (kcal/day) | 2082 | 1759 | 1922 | 2513 | *** |
| Protein (% of energy) | 16.7 | 17.6 | 16.6 | 16.0 | ** |
| Fat (% of energy) | 33.5 | 32.7 | 33.2 | 34.5 | |
| Carbohydrates (% of energy) | 49.1 | 50.4 | 50.2 | 46.8 | |
| Saturated Fat (grams/1000kcal) | 12.0 | 12.3 | 11.8 | 11.9 | ** |
| Cholesterol (mg/1000kcal) | 153.7 | 158.9 | 156.9 | 146.2 | |
| Fiber (grams/1000kcal) | 9.4 | 11.0 | 9.3 | 8.1 | *** |
| Sodium (mg/1000kcal) | 1682.5 | 1773.9 | 1684.9 | 1599.6 | ** |
| Fruit Intake (cup equiv.) | 1.1 | 1.3 | 1.0 | 1.0 | *** |
| Vegetable (cup equiv.) | 1.5 | 1.2 | 1.3 | 1.8 | *** |
| Red Meat^ (oz equiv.) | 1.9 | 0.9 | 1.5 | 3.0 | *** |
| Added Sugar (tsp equiv.) | 16.0 | 10.3 | 15.3 | 21.8 | *** |

Tests of Significance = *** p<0.01, ** p<0.05, * p<0.1
Chi-Square Test for Categorical Variables, Adjusted Wald Test for Continuous Variables
^excludes organ and cured meats

Table 3.8: Association between Food Security Status and Dietary Profiles, Standardized Latino Adult Respondents, National Health and Nutrition Examination Survey, 2013-2018 (n=2,049)

| | **Model 1** | | | **Model 2** | | | **Model 3** | | | **Model 4** | | | **Model 5** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***Solid Fats, Cheese, & Refined Carbs* Profile** | | | ***Beans and Legumes Profile*** | | | ***Plant-Based* Profile** | | | ***Vegetables* Profile** | | | ***Alcohol and Carbohydrate* Profile** | | |
| | βcoef | [95 % CI] | | βcoef | [95 % CI] | | βcoef | [95 % CI] | | βcoef | [95 % CI] | | βcoef | [95 % CI] | |
| **Food Security Status** | | | | | | | | | | | | | | | |
| High/Marginal Food Security | ref | | | ref | | | ref | | | ref | | | ref | | |
| Low Food Security | 0.05 | -0.14 | 0.25 | 0.08 | -0.09 | 0.26 | -0.13 | -0.32 | 0.05 | -0.18** | -0.36 | -0.01 | -0.10 | -0.27 | 0.07 |
| Very Low Food Security | 0.00 | -0.26 | 0.26 | 0.09 | -0.25 | 0.44 | -0.18** | -0.32 | -0.03 | -0.27*** | -0.44 | -0.10 | -0.32** | -0.61 | -0.03 |
| **Covariates** | | | | | | | | | | | | | | | |
| Age | -0.01*** | -0.02 | -0.01 | 0.01** | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01*** | 0.00 | 0.01 | 0.00 | -0.01 | 0.00 |
| Sex | | | | | | | | | | | | | | | |
| Female | ref | | | ref | | | ref | | | ref | | | ref | | |
| Male | 0.55*** | 0.36 | 0.74 | 0.27** | 0.06 | 0.49 | 0.04 | -0.22 | 0.30 | 0.04 | -0.08 | 0.15 | 0.37*** | 0.20 | 0.53 |
| Income | | | | | | | | | | | | | | | |
| <20,000 | ref | | | ref | | | ref | | | ref | | | ref | | |
| 20,000-34,999 | -0.16 | -0.47 | 0.15 | 0.14 | -0.25 | 0.52 | -0.09 | -0.21 | 0.03 | 0.26** | 0.03 | 0.49 | 0.00 | -0.18 | 0.20 |
| 35,000+ | 0.01 | -0.17 | 0.19 | 0.02 | -0.24 | 0.27 | 0.07 | -0.11 | 0.26 | 0.35*** | 0.18 | 0.53 | -0.11 | -0.34 | 0.12 |
| Educational Attainment | | | | | | | | | | | | | | | |
| <High School Diploma | ref | | | ref | | | ref | | | ref | | | ref | | |
| High School Diploma or Equiv. | -0.19** | -0.36 | -0.02 | -0.14 | -0.41 | 0.14 | 0.08 | -0.06 | 0.23 | 0.04 | -0.11 | 0.20 | 0.03 | -0.18 | 0.24 |
| Some College or Tech | -0.14* | -0.3 | 0.01 | -0.19 | -0.47 | 0.10 | 0.44** | 0.02 | 0.85 | 0.06 | -0.08 | 0.21 | 0.03 | -0.18 | 0.25 |
| Nativity & Duration | | | | | | | | | | | | | | | |
| Born in the US | ref | | | ref | | | ref | | | ref | | | ref | | |
| <10 years | -0.08 | -0.34 | 0.18 | 0.47*** | 0.17 | 0.77 | 0.09 | -0.13 | 0.31 | 0.24* | -0.04 | 0.51 | -0.40*** | -0.34 | 0.18 |
| 10 years+ | -0.05 | -0.23 | 0.12 | 0.39*** | 0.16 | 0.64 | 0.27 | -0.21 | 0.76 | 0.37*** | 0.19 | 0.56 | -0.41*** | -0.23 | 0.13 |
| Constant | 0.59*** | 0.26 | 0.92 | -0.05 | -0.12 | 0.24 | -0.33** | -0.58 | -0.07 | -0.30*** | -0.39 | -0.08 | 0.32* | -0.06 | 0.70 |

*Tests of Significance = *** p<0.01, ** p<0.05, * p<0.1*

# CHAPTER 4

# Food insecurity and Type 2 Diabetes among Latinos: Examining Neighborhood Cohesion as a Protective Factor[2]

## INTRODUCTION

### Food insecurity and type 2 diabetes

Food insecurity, or the lack of access to enough food for an active, healthy life, is an important risk factor for type 2 diabetes (T2D).[7,18] The relationship between food insecurity and T2D has been consistently established in cross-sectional studies across different samples and geographical regions.[20–24] This is especially evident by the higher prevalence of diabetes of people living in households that are food-insecure compared to those living in food-secure households. One study showed a 3% difference in diabetes prevalence among low-income adults living in food-insecure households (10.2%) compared to those in food-secure households (7.4%) in the United States.[25] In addition, in the United States and Canada, food-insecure adults of different races/ethnicities are two to three times more likely to have T2D compared to their food-secure counterparts, even after adjusting for other risk factors such as lifestyle factors, income, employment, and physical measures.[22,23]

While the relationship between food insecurity and T2D is robust, the underlying pathways, as well as potential moderators of this association, are not yet fully understood.[21] One potential pathway between food insecurity and T2D can be through obesity. Food insecurity is independently associated with obesity and obesity is a risk

[2] This chapter has been submitted to the *Journal of Racial and Ethnic Health Disparities*

factor for insulin resistance and T2D.[20,23] Food insecurity can also result in inconsistent eating patterns. These inconsistent eating patterns or meal irregularities can have detrimental physiological effects on the endocrine system, hunger, and metabolism including a decrease in the thermic effect of food (increase in metabolic rate)[73] which is associated with increased weight and insulin resistance.[74]A 2016 randomized-controlled trial among normal-weight women found that meal irregularity was associated with increased glucose sensitivity and decreased thermic effect of food.[73] Individuals with prolonged food insecurity experience chronic stress,[146] which may result in negative health effects. This is evident from research that has found that the elevation of cortisol from stress has been found to increase adiposity, a precursor to T2D.[60] Food insecurity experienced as a chronic stressor promotes a stress response, which may result in compensatory eating behaviors, such as the selection of energy-dense foods over fresh produce, which increases glycemic loads and risk of T2D.[147,148] This pathway suggests that individuals experiencing food insecurity may rely on the consumption of high-caloric-dense foods to cope with their food insecurity and this process can lead to obesity.

The psychological response from food insecurity is well documented and may also be a pathway to T2D. Food insecure individuals are more likely to experience shame, guilt, anxiety, worry, and intensifying depressive symptoms.[58,59] Food insecure individuals with T2D report more mood disorders and depressive symptoms overall compared to their food-secure counterparts.[20] Food insecurity in and of itself is a unique type of stressor which may exacerbate physiological responses including cortisol secretion which plays a detrimental role in contributing to blood glucose levels and T2D.[61,62]

There are distinct health disparities among different racial/ethnic populations in the United States when examining food insecurity and its relation to T2D. Latino adults are disproportionately affected by T2D, with a higher prevalence of diagnosed T2D (12.5%) compared to non-Hispanic whites (7.5%).[1] Additionally, the prevalence of food insecurity is considerably higher among Latino households (18.0%) than the national average (11.8%).[2] The association between food insecurity and T2D is also stronger among Latinos compared to other racial/ethnic groups, with Latinos being more likely to have T2D when food insecure compared to other racial/ethnic groups, underscoring the importance of examining this association in depth.[18,22,23] Latina adults experiencing very low food security have been found to be 3.3 times more likely to have T2D compared to their food secure or low food secure counterparts after controlling for age, employment status, acculturation, waist circumference, and lifestyle characteristics.[23] Other racial/ethnic groups do not exhibit such a robust association between food insecurity and T2D.[32]

Examining factors that can explain or disrupt the association between food insecurity and T2D can better inform how to address the adverse effects of food insecurity, especially among Latinos. Studies that have focused on Latinos/as have examined individual-level behaviors and disease-oriented measures (i.e. depression), as potential mediators and moderators. For example, a case-control study among Latinas examined potential mediators to determine whether depressive symptoms, body mass index, marital status, nutrition knowledge, education, access to a car, and SNAP participation were independently related to both food insecurity and T2D but did not find any significant risk factors associated with both food insecurity and T2D.[23] The authors found a robust association between elevated depressive symptoms and food insecurity, but no association

between depressive symptoms and T2D among the sample of Latinas.[23] In a separate study that examined low-income Latinos patients with T2D, participants reporting trade-offs related to material need insecurity (including food insecurity) reported higher rates of depression, stressful life events, and barriers to access to care compared to their counterparts with no trade-offs related to material need insecurity.[175] While these two studies examined intrapersonal factors among Latinos, interpersonal and psychosocial factors have not been examined as mediators of moderations of the relationship between food insecurity and T2D. Investigating psychosocial constructs and characteristics of the social environment may help potential factors that can be modified or addressed to reduce the relationship between food insecurity and T2D among Latinos.

**Neighborhood social cohesion as a moderator**

Other studies have established that psychosocial factors can buffer the negative influence of food insecurity on health outcomes. For example, one study found a buffering effect of *social support* against food insecurity's association with depression among Latinos adults with T2D.[142] Among Latino adults, the predicted probability of having depression with low social support and having high food insecurity was above 0.8, whereas the predicted probability of having depression with high school support and having high food insecurity was less than 0.1.[142] This buffering effect may arise from family, friends, and others providing resources to those experiencing food insecurity protect mental health such as food, money, and/or emotional support.[124] This shows that social support among Latinos can lessen negative emotions associated with food insecurity that may exacerbate

their risk for T2D such as compensatory eating behaviors associated with negative emotions.[176]

Community-level psychosocial resources, such as neighborhood social cohesion, can likewise be important factors at the intersection of T2D[14] and food security.[98–100,104] *Social cohesion* is a concept that suggests that trusting relationships in a community yield important resources that may be used in the exchange of goods and services. This interpersonal phenomenon can be tapped by community members and used for goods such as food and services such as transportation. Social cohesion is often conceptualized as occurring within a set geographic place, most often in one's neighborhood. Neighborhood social cohesion, or neighborhood cohesion can be measured at the individual level (individual perception of neighborhood social cohesion), the neighborhood (average magnitude of individual-level perceptions of neighborhood social cohesion), or both. [11,16,17] Neighborhood cohesion, as measured by individual perception of neighborhood cohesion, has been found to improve safety and serve as a protective factor[16,18] against food insecurity among low-income families living in low-income neighborhoods. [11] Trusting neighborhood relationships can provide a resource for low-income families living in low-income neighborhoods, and this resource can help protect families from the experience of food insecurity[101] as well as improve safety and other aspects of health.[101] Kawachi[94,95] and Berkman[94] propose that neighborhood cohesion can serve as a protective factor and affect health via psychosocial processes, influencing health behaviors, and increasing access to services and amenities. For example, cohesion within a neighborhood can impact psychosocial processes by providing affective support and act as a source of self-esteem and mutual respect. Neighborhood cohesion has had a significant independent effect on

glycohemoglobin (HbA1c) levels with more neighborhood cohesion increasing glycemic control (lower HbA1c levels).[96] This suggests that neighborhood cohesion may be a protective factor against both food insecurity and T2D independently.

There are at least two distinct mechanisms by which neighborhood social cohesion might buffer against the impact of food insecurity on T2D. The first mechanism is the direct sharing of services and resources among a socially cohesive group. The second mechanism is indirect access to resources available through members within this group, e.g. via sharing of knowledge, information, and linkage to resources and services.[101,177] For example, neighbors may provide direct assistance by sharing a meal, extra food, cash, or a gift card to a restaurant or grocery store. Neighbors may provide indirect assistance by referring families or individuals who are experiencing food insecurity to a local community service, such as a food pantry or food bank, to families or individuals who are experiencing food insecurity. These examples highlight the potential benefits of neighborhood cohesion within the context of food insecurity.

Latinos' experiences of neighborhood social cohesion may be a proxy for instrumental support outside the household and act as a buffer against the adverse health effects of food insecurity including T2D. A 2017 qualitative study among food pantry recipients, who were primarily Spanish-speaking Latinos, found that recipients shared food and reciprocally provided social support to their food-insecure neighbors.[114] These findings suggest that neighborhood cohesion and social capital derived from neighborhood cohesion may serve as an important community-level resource that Latinos utilize as a coping mechanism when food insecure. This has not been tested empirically in quantitative data, however. It's also possible that neighborhood social cohesion may not be a moderator

of the relationship between food insecurity and T2D, but instead a potential determinant of food security.

Understanding if high neighborhood cohesion buffers the impact of food insecurity could inform future public health policy and interventions by highlighting the importance of neighborhood interpersonal processes. In this chapter, I use the National Health Interview Survey, a nationally representative sample, to determine whether neighborhood cohesion moderates the association between food security status and T2D among Latinos nationwide. I hypothesize 1) that food security status will be associated with T2D among Latino adults and 2) that neighborhood cohesion will moderate the relationship between food security status and T2D, such that high neighborhood cohesion will result in a weaker association between food security status and T2D.

**METHODS**

I analyzed data from the 2013-2018 National Health Interview Survey (NHIS). The NHIS is an annual, cross-sectional household interview survey conducted by the Centers for Disease Control and Prevention that gathers health-related data in a nationally representative sample of the civilian, non-institutionalized U.S. population. The sample is selected using a complex, stratified, multistage probability cluster design. I limited the sample to respondents who self-reported Latino ethnicity, were over the age of 18, and who responded to variables of interest including covariates (n=23,478) I used listwise deletion to handle missing data among the variables of interest. The percent missing (7%) is below the range that is considered problematic (10% or more) for missing data biases.[178] All statistical analyses were conducing using Stata 14.[179]

## Measures

*Food security status* was measured by utilizing the validated USDA's 10-item adult food security module on the NHIS. Three categories were assigned according to the USDA guidelines[67]: high/marginal food security (0), low food security (1), very low food security (2). The level of food security is determined by the number of affirmative responses to the 10-item questionnaire module. An example of one of the questions is "[In the last 12 months], were you ever hungry but didn't eat because there wasn't enough money for food?" Respondents who provided affirmative responses to any of the items were considered fully food secure. Those who provided 0-2 affirmative responses for a household were considered to have high/marginal food security. Those who provided 3-5 affirmative responses for a household were considered to have low food security status. Those who provided 6-10 affirmative responses for a household were considered to have very low food security.

*Type 2 Diabetes* was measured by two questions, "Has a doctor ever told you that you have diabetes?" and if respondents answered yes, the respondent is asked to specify "Type 1 or Type 2 Diabetes?". T2D was distinguished if respondents answered "yes" to the first question and specified T2D in their response to the second question. Responses were dichotomized to either 0 (no) or yes (1).

*Neighborhood cohesion* can be measured by individual perceptions of neighborhood social cohesion.[101] Scholars often use individual perceptions of neighborhood social cohesion[180,181] as it has been found to be valid and reliable. Additionally, when trying to obtain more objective measures of neighborhood social cohesion, there is difficulty in obtaining consensus from residents about a definition and boundary for their neighborhood.[101] In this study, neighborhood cohesion was measured using four questions

modified from an original scale developed by the Project on Human Development in Chicago Neighborhoods Community Survey.[180] The four items have been used in other studies to examine neighborhood cohesion and health outcomes.[101,181–184] Participants rated agreement or disagreement on a 4-point scale (1, definitely agree; 2, somewhat agree; 3, somewhat disagree; and 4, definitely disagree) with the following 4 statements: 1) People in this neighborhood help each other out; 2) There are people I can count on in this neighborhood; 3) People in this neighborhood can be trusted; and 4) This is a close-knit neighborhood. Participant responses were reverse coded; a higher score equated to higher neighborhood social cohesion.[180] A neighborhood social cohesion score was constructed by summing the responses to the questions, with a possible range of scores from 4 to 16.[183,184] Similar to Yi et. al, neighborhood social cohesion was dichotomized for analyses, categorized as at or above the median score (13 and higher) or below the median score[183] for simplified interpretation of the interaction terms.

*Covariates* included: age (years); sex (male, female); education level (less than high school, high school diploma or equivalent, some college or technical training, university graduate or greater); poverty level (less than 1.0 of the federal poverty line, 1.00-1.99, and 2.0 and greater); having health insurance (yes, no); nativity (US-born or foreign-born). These variables may be associated with both food security status and T2D simultaneously.[8,20,61] I also controlled for length of time living in the neighborhood (Less than 1 year, 1-3 years, 4-10 years, 11-20 years, 20+ years) since this variable may influence perceptions of neighborhood cohesion. [101,180,183] Lastly, I controlled for family type (one adult and no children, multiple adults and no children, one adult and 1+ children, multiple adults and 1+ children) since the USDA adult food insecurity module does account for

children and household food insecurity is more prevalent among households with children and one adult.[185]

**Data Analyses**

I conducted a series of logistic regressions to determine the potential interactive relationship between food security status and neighborhood cohesion to T2D. I first examined the unadjusted association between food security status and T2D (Model 1) to establish the primary association between food security status and T2D. I then examined the association between food security status and T2D after controlling for covariates (Model 2). I then added neighborhood social cohesion in Model 3. Lastly, I included an interaction term between food security status and neighborhood social cohesion on T2D (Model 4) to test whether neighborhood social cohesion moderated food security status' association with T2D. Additionally, I conducted post hoc analyses such as adjusted Wald tests to test the difference between the regression coefficients and an f-test of overall significance.

**RESULTS**

**Sample Characteristics**

The sample was 53.5% female and 44.8% native-born (Table 1). The average age of respondents was 43.0 years. The prevalence of self-reported T2D was 10.8% and a combined 15.7% of respondents had low or very low food security. A majority of respondents lived in their neighborhoods for less than 10 years (70.0%) and were below 200% of the federal poverty line (51.7%). In addition, 38.1% of respondents perceived themselves as living in a neighborhood with high cohesion.

**Multivariable Regression Results**

There was a significant association between low food security and T2D (OR=1.64, 95% CI: 1.42-1.89) and very low food security and T2D (OR=1.93, 95% CI:1.62, 2.30) in my unadjusted model (Model 1, Table 2). People with low or very low food security had a higher odds of having T2D compared to their food-secure counterparts. The odds of T2D for respondents with low food security (AOR=1.84, 95% CI: 1.56-2.17) and very low food security (AOR=2.00, 95% CI: 1.64-2.43) remained significant after adjusting for covariates (Model 2, Table 2). Similar to Model 1, people with low or very low food security had a higher odds of having T2D compared to their food secure counterparts after taking differences in age, sex, education level, poverty, having health insurance, nativity, and length of time living in the neighborhood into account. In Model 3, neighborhood cohesion was associated with T2D. People who reported having high neighborhood cohesion had a lower odds (AOR=0.86, 95% CI: 0.76-0.97) of T2D compared to those who reported having low neighborhood cohesion. When neighborhood cohesion was added to the model, the association between food security status and T2D remained in the same direction as in Model 2.

Model 4 included interaction terms between food security status and neighborhood cohesion. There was not a significant interaction between food security status and neighborhood social cohesion on T2D. (Model 4, Table 2). Among respondents who reported low food security and high neighborhood cohesion, there was no significant difference in odds of having T2D compared to their food-secure counterparts with low neighborhood cohesion (AOR=1.31, 95% CI: 0.92-1.88). Among respondents who reported very low food security and high neighborhood cohesion, there was no significant difference

in odds of T2D compared to their food-secure counterparts with low neighborhood cohesion (AOR=0.92, 95% CI: 0.61-1.38).

**Sensitivity Checks**

I ran my analyses on only working-age adults since older adults have a higher T2D prevalence. However, the results from Models 1-4 did not change by excluding older adults. I also examined a different outcome variable of self-reported T2D combined with impaired glucose tolerance to include those with self-reported prediabetes but the overall results did not change.

**DISCUSSION**

This study is the first to test whether neighborhood cohesion moderates the association between food security status and T2D among Latinos nationwide. After controlling for covariates, I found that Latinos with low food security were 1.84 times more likely to have T2D and that those with very low food security were 2.0 times more likely to have T2D, compared to those who were food secure. Originally, I posited that food security status would be associated with T2D, and that this association would differ by level of neighborhood cohesion such that those with higher neighborhood cohesion would be less likely to have T2D when food insecure. To my knowledge, this hypothesis has not been empirically tested with quantitative data. Although food security status was associated with T2D, neighborhood cohesion did not moderate the association. While qualitative work has found Latino individuals who are food insecure to utilize their social connections to share food and resources[114], I did not find that these relationships made any difference in the association between food insecurity and T2D. I did find that Latinos reporting high

levels of neighborhood cohesion were 0.86 less likely to have type T2D compared to their counterparts who reported low levels of neighborhood cohesion.

My null findings add to the existing work in the food insecurity literature which has examined moderators of food insecurity's association with health outcomes among Latinos. Although I did not detect a statistically significant interaction between food insecurity and neighborhood cohesion on T2D, other studies have identified buffers against food insecurity on health outcomes. One study, which did not focus on the focal relationship of food insecurity and T2D, but rather Latinos diagnosed with T2D, found that social support buffered the effect against food insecurity's association with negative emotions.[186] Additionally, when it comes to food insecurity and obesity, a psychosocial measure of maternal stress has been found to be a moderator between food insecurity and obesity among youth.[187]

One possible explanation for my null findings is that neighborhood cohesion may instead be a precursor to food insecurity, rather than a moderator/buffer of food insecurity on T2D. Low neighborhood cohesion may lead to less instrumental support and tangible benefits that determine household levels of food security. Martin et al. found that community-level social capital, including neighborhood cohesion, is associated with decreased risk of hunger.[100] Another study found that higher neighborhood social cohesion is associated with higher food security among households with and without children in the U.S.[104] However there is conflicting evidence against this idea, as a different study found that neighborhood social cohesion was not associated with food security (reduction in food insecurity) indicating that it may not be a precursor to food insecurity.[23] Overall, this study does not suggest that neighborhood cohesion is an unimportant factor. In fact, the

literature suggests that trusting neighborhood relationships can provide a resource for low-income families living in low-income neighborhoods[105], and that this resource can help protect families from the experience of food insecurity. Neighborhood cohesion may affect levels of food insecurity that a household experiences but I found that it did not alter the outcome of T2D. This could be because T2D is too distal or because of the limitations of the measurement of T2D or the cross-sectional nature of the data I examined.

This study had a number of limitations. The NHIS consists of cross-sectional data that cannot be used to determine the causality or directionality of the models. Additionally, all measures were self-reported and thus are at risk of recall and social desirability biases.[137] T2D was measured by a respondent reporting whether a physician told them they have diabetes. This form of measurement excludes respondents who may not have access to a physician and may thus be undiagnosed. I adjusted for health insurance status to address this possibility, however. Individuals with undiagnosed T2D are less likely to have regular access to care and more likely to be low-income and represent a high proportion of the Latino population in the US.[188] This may have resulted in underestimating Latinos with T2D, thus generating more conservative results when testing the interaction and my non-significant results.

Perceived social neighborhood cohesion might not align with the actual neighborhood environment because traditionally marginalized communities have a reluctance to trust those around them.[189,190] An individual's perception of neighborhood social cohesion and the neighborhood average magnitude of perceived social cohesion, can also be quite different.[101] This is a limitation of the study (using a perception variable). However, there is also difficulty obtaining consensus from residents about a definition and

boundary for their neighborhood.[101] Thus, residents of a neighborhood will have different perceptions of neighborhood social cohesion.[101] Inferences drawn from using self-reported measures of neighborhood cohesion should consider that social cohesion may be a shifting definition and defined less spatially or proximally once people sort themselves socially within groups by family, affinity, ideology, identity, etc.

Past studies examining neighborhood cohesion[95,100,104,105] as well as this study were not specific to Latinos who may live in immigrant enclaves. Immigrant enclaves may be a neighborhood-level covariate when examining the relationship between food insecurity, neighborhood, and T2D among Latinos. Compared to their counterparts who live in neighborhoods with a low immigrant composition, Latinos living in neighborhoods with a high immigrant composition have diets lower in fat and processed foods as well as overall better access to healthy food a major component of food insecurity.[83] However, Latinos living in immigrant enclaves also report worse social environments including social cohesion compared to their counterparts who live in neighborhoods with a low immigrant composition.[83] Future research inquiries can use multi-level modeling to test both neighborhood-level measures and individual-level perception of a neighborhood. Further research examining neighborhood-level measures may want to consider and control for the demographic and cultural makeup of neighborhoods, for example, by measuring the percentage of coethnicity or percentage of the immigrant population in a neighborhood. Additionally, future research should examine more potentially proximal measures of health including depression and obesity, rather than T2D.

In summary, the study results indicate that food insecurity and neighborhood cohesion are significantly associated with T2D, but neighborhood cohesion does not

moderate the association between food insecurity and T2D. Perceived neighborhood cohesion might not align with the actual neighborhood environment and T2D may be too distal of a health outcome to test the protective effect of neighborhood social cohesion.

Table 4.1: Sample Description, National Health Interview Survey 2013-2018: Latino Adults (n=23,478)

| | |
|---|---|
| **Demographics** | |
| Mean Age | 43.0 |
| Gender, % | |
| Female | 53.5 |
| Male | 46.5 |
| Education, % | |
| Less than High School | 30.8 |
| High School Diploma or Equivalent | 25.4 |
| Some College or Technical Training | 27.2 |
| University Grad+ | 16.5 |
| Poverty Level Ratio, % | |
| Less than 1.0 | 23.6 |
| 1.0-1.99 | 28.1 |
| 2.0+ | 48.2 |
| Born in the United States, % | 44.8 |
| Family Type, % | |
| One Adult, No Children | 23.2 |
| Multiple Adults, No Children | 29.9 |
| One Adult, 1+ Children | 7.5 |
| Multiple Adults, 1+ Children | 39.4 |
| Currently Has Health Insurance, % | 75.1 |
| **Food Security Status, %** | |
| High/Marginal Food Security | 84.3 |
| Low Food Security | 9.9 |
| Very Low Food Security | 5.8 |
| **Type 2 Diabetes Prevalence, %** | 10.8 |
| **Neighborhood Characteristics** | |
| Mean level of Neighborhood Cohesion (Range of values: 4-16) | 11.5 |
| Length of Time Living in Present Neighborhood, % | |
| Less than 1 year | 14.3 |
| 1-3 years | 26.3 |
| 4-10 years | 29.4 |
| 11-20 years | 17.1 |
| 20+ years | 12.8 |

Table 4.2: National Health Interview Survey 2013-2018: Latino Adults (n=23,478), Odd Ratios of Having Type 2 Diabetes via Logistic Regression

| | **Model 1** | | | **Model 2** | | | **Model 3** | | | **Model 4** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Unadjusted Main Effects of Food Security Status** | | | **Food Security Status, Controls** | | | **Food Security Status, Main Effects of Neighborhood Cohesion, Controls** | | | **Interaction Between Food Security Status and Neighborhood Cohesion** | | |
| | OR | [95 % CI] | | OR | [95 % CI] | | OR | [95 % CI] | | OR | [95 % CI] | |
| **Food Security Status** | | | | | | | | | | | | |
| High/Marginal Food Security | ref | | | ref | | | ref | | | ref | | |
| Low Food Security | 1.64** | 1.42 | 1.89 | 1.84** | 1.56 | 2.17 | 1.83** | 1.55 | 2.15 | 1.67** | 1.35 | 2.05 |
| Very Low Food Security | 1.93** | 1.62 | 2.30 | 2.00** | 1.64 | 2.43 | 1.97** | 1.62 | 2.4 | 2.01** | 1.61 | 2.51 |
| **Neighborhood Cohesion** | | | | | | | | | | | | |
| Low | | | | | | | ref | | | ref | | |
| High | | | | | | | 0.86* | 0.76 | 0.97 | 0.84* | 0.74 | 0.96 |
| **Interaction: FSS, Neighborhood Cohesion** | | | | | | | | | | | | |
| Low Food Security, High Cohesion | | | | | | | | | | 1.31 | 0.92 | 1.88 |
| Very Low Food Security, High Cohesion | | | | | | | | | | 0.92 | 0.61 | 1.38 |
| **Covariates** | | | | | | | | | | | | |
| Age | | | | 1.06** | 1.06 | 1.07 | 1.06** | 1.06 | 1.07 | 1.06** | 1.06 | 1.07 |
| Gender | | | | | | | | | | | | |
| Male | | | | ref | | | ref | | | ref | | |
| Female | | | | 0.84** | 0.74 | 0.94 | 0.83** | 0.74 | 0.94 | 0.84** | 0.74 | 0.94 |
| Family Type | | | | | | | | | | | | |
| One adult, no children | | | | ref | | | ref | | | ref | | |
| Multiple Adults, No Children | | | | 1.24** | 1.08 | 1.42 | 1.24** | 1.08 | 1.43 | 1.24** | 1.08 | 1.43 |
| One Adult, 1+ Children | | | | 0.99 | 0.76 | 1.28 | 0.99 | 0.76 | 1.28 | 0.99 | 0.76 | 1.28 |
| Multiple adults, 1+ Children | | | | 1.13 | 0.97 | 1.32 | 1.14 | 0.97 | 1.33 | 1.14 | 0.97 | 1.33 |
| Ratio of Family Income To Poverty Threshold | | | | | | | | | | | | |
| Less than 1.0 | | | | ref | | | ref | | | ref | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.0-1.99 | 0.83** | 0.71 | 0.95 | 0.83** | 0.71 | 0.95 | 0.83** | 0.71 | 0.95 |
| 2.0+ | 0.69** | 0.58 | 0.81 | 0.69** | 0.59 | 0.81 | 0.69** | 0.59 | 0.81 |
| Year | | | | | | | | | |
| 2013 | ref | | | ref | | | ref | | |
| 2014 | 0.87+ | 0.74 | 1.01 | 0.87+ | 0.74 | 1.01 | 0.87+ | 0.74 | 1.01 |
| 2015 | 0.99 | 0.84 | 1.15 | 0.98 | 0.84 | 1.15 | 0.98 | 0.84 | 1.15 |
| 2016 | 0.99 | 0.82 | 1.20 | 0.99 | 0.82 | 1.20 | 0.99 | 0.82 | 1.20 |
| 2017 | 1.00 | 0.83 | 1.20 | 1.00 | 0.83 | 1.20 | 1.00 | 0.83 | 1.20 |
| 2018 | 1.01 | 0.84 | 1.21 | 1.01 | 0.84 | 1.22 | 1.01 | 0.84 | 1.22 |
| Educational Attainment | | | | | | | | | |
| Less than High School | ref | | | ref | | | ref | | |
| High School Diploma or Equiv. | 0.83* | 0.72 | 0.97 | 0.84* | 0.72 | 0.97 | 0.84* | 0.72 | 0.97 |
| Some College or Tech | 0.80** | 0.69 | 0.93 | 0.81** | 0.69 | 0.93 | 0.81** | 0.70 | 0.93 |
| Bachelor's+ | 0.54** | 0.44 | 0.65 | 0.54** | 0.44 | 0.66 | 0.54** | 0.44 | 0.66 |
| Duration of Living in Present Neighborhood | | | | | | | | | |
| Less than 1 year | ref | | | ref | | | ref | | |
| 1-3 years | 1.11 | 0.90 | 1.37 | 1.11 | 0.90 | 1.37 | 1.11 | 0.90 | 1.37 |
| 4-10 years | 1.23* | 1.01 | 1.51 | 1.24* | 1.01 | 1.53 | 1.24* | 1.01 | 1.52 |
| 11-20 years | 1.34** | 1.09 | 1.65 | 1.36** | 1.10 | 1.68 | 1.36** | 1.10 | 1.68 |
| 20 years+ | 1.19 | 0.96 | 1.48 | 1.21+ | 0.98 | 1.5 | 1.21+ | 0.97 | 1.50 |
| Nativity/Born in the US | 1.50** | 1.33 | 1.70 | 1.51** | 1.34 | 1.71 | 1.51** | 1.34 | 1.71 |
| Uninsured | 0.70** | 0.60 | 0.82 | 0.70** | 0.59 | 0.82 | 0.70** | 0.59 | 0.82 |

Tests of Significance = +p<0.1, *p<0.05, **p<0.01

# CHAPTER 5
# CONCLUSION

*Summary*

In this dissertation, I examined the relationship between food security status, diet, and type II diabetes (T2D) among Latino adults. I used data from state and nationally representative sources. I found that specific components of my conceptual framework (Figure 1.1) were supported, while others were not. I found that among Latinos in California, food security status was associated with both T2D and self-management of T2D, and these relationships differed by nativity status and duration of residence in the United States. Whereas Latinos born in the United States and longer stay immigrants (10 years or more in the US) Latinos had a higher odds of reported T2D if they were food insecure or very food insecure, recent immigrant (less than 10 years in the US) Latinos did not show significant associations between food security status and T2D. When examining the management of T2D, there were no differences by food security status among Latinos born in the United States, but there were among Latino immigrants. Latino immigrants who were food insecure had a lower odds of managing their T2D well compared to their food-secure counterparts with T2D. These findings support a component of my conceptual framework where I argue that nativity and duration of residence in the United States is a moderator, or effect modifier, of the relationship between food security status and T2D among Latinos.

These findings validate previous studies that have found that increased food insecurity is associated with a higher likelihood of T2D as well as poor glycemic control[23,191–193] These findings are significant because they imply that as immigrant Latinos

live longer in the United States, their odds of having T2D when food insecure is similar to Latinos born in the United States. This can be attributed to both the long latent period of T2D as well as health selection among migrants. Although recent immigrant Latinos report higher rates of food insecurity, they are less likely to have T2D. Latino immigrants have lower T2D prevalence than their US-born counterparts, a pattern that is attributed to the selectivity hypothesis of immigrant health.[50] This hypothesis argues that immigrants are selected on characteristics, such as better health patterns, that make them more likely to migrate compared to those left behind in the country of origin and that these characteristics contribute to better outcomes of post-migration health compared to the US-born. However, this health advantage tends to decrease with a longer duration of living in the United States.[50] My findings from chapter 2 align with this theory. Similar patterns have been found for obesity, with recent immigrants having the highest levels of food insecurity, but not displaying a significant association between food insecurity and obesity.[42] In contrast, food insecurity is associated with a higher likelihood of obesity among those born in the US and immigrants with longer duration in the US.[42]

In Chapter 3, I generated and explored dietary profiles of Latino adults in the United States. This is the first study, to my knowledge, to utilize an *a posteriori* approach to derive dietary profiles and examine their associations with food security status among Latino adults. I found that food security status was associated with specific dietary profiles among Latinos. In contrast to previous research, I found differences in five dietary profiles by food security status, but not always in the expected directions. I found that Latinos who are food insecure are not more likely to consume low-quality diets, high in solid fats, cheese, refined grains, and added sugars, compared to those who are food secure. Instead, I found that

Latinos experiencing food insecurity are less likely to consume high-quality protective foods (eg, such as within the Plant-based and Vegetable profiles) compared to those who are food secure. This finding supports a component of my conceptual framework where I argue that food security status is related to dietary intake.

My findings from this chapter are significant and counter previous studies and theoretical frameworks presented throughout the food insecurity literature. The energy-density cost framework posits that individuals experiencing food insecurity are more likely to select energy-dense and hyperpalatable foods as a deliberate strategy to save money and increase energy intake.[144] My findings challenge this notion at least among Latino adults. Instead, Latinos experiencing the highest level of food insecurity were less likely to consume vegetables, plant-based foods, and alcohol and carbohydrates *(*alcohol, potatoes, and added sugar) compared to their food-secure counterparts, but not more likely to consume diets high in hyperpalatable foods such as solid fats, cheese, and refined carbohydrates. This suggests that Latino adults, when food-insecure may not be able to access and afford and/or consume higher-quality foods (vegetables, fruits, nuts, etc). Future efforts to increase the intake of vegetables and fruits, specifically among food insecure populations should not just focus on individual dietary change, but instead encompass community-focused and macro-level interventions that address food insecurity and the local food environment by increasing accessibility and affordability to fresh fruits and vegetables.

One component of my conceptual framework that was not supported through my research findings is that neighborhood social cohesion moderates the association between food security status and T2D among Latino adults in the United States. In Chapter 4, I did

not find that neighborhood social cohesion moderates this relationship between food security status and T2D among Latinos. Neighborhood social cohesion may instead be a precursor to food insecurity, rather than a moderator of food insecurity on T2D. These findings do not suggest that neighborhood social cohesion is unimportant within this research area. In fact, the literature suggests that trusting neighborhood relationships can provide a resource for low-income families living in low-income neighborhoods and that this resource can help protect families from the experience of food insecurity. Neighborhood social cohesion may affect levels of food insecurity that a household experiences and in chapter four I did not find it altered the outcomes of T2D. This could be because T2D is too distal or because of the limitations of the data and study.

*Limitations*

All measures in the studies were based on self-reported survey data and thus are at risk of both recall and social desirability biases. I used self-reported measures of T2D versus objectively, clinically diagnosed measures (i.e. glycohemoglobin levels). Clinically diagnosed measures should be used in future studies. Additionally, all studies utilized a cross-sectional study design which cannot be used to infer causality or directionality of the models. In the study examining diet, household food insecurity is assessed over the past 12 months, whereas dietary intake is assessed at the time of the survey. This may result in misclassification because food insecurity can be a transient or cyclical condition and can vary over time. Dietary patterns can also be subject to changing food security status. Future studies examining food security status and T2D should utilize more rigorous study designs such as longitudinal prospective cohorts in order to measure food security status and other factors of interest, such as dietary intake and psychosocial constructs, over time.

*Implications and Relevance to Population Health*

The findings from my dissertation have important implications for the overall health of Latinos and inform future research as well as interventions. One, this dissertation contributes to the literature by identifying the most at-risk Latinos (by nativity status and duration of residence) of the relationship between food security status and T2D. Two, this dissertation identifies nuances in dietary intake by different levels of food security among Latinos by highlighting that food insecure Latinos are less likely to eat vegetables and plant-based foods but not more likely to eat diets high in hyperpalatable foods such as solid fats, cheese, and refined carbohydrates. Lastly, other psychosocial factors besides neighborhood social cohesion should be empirically tested to see how these factors might reduce food insecurity's adverse impact among Latinos. Future research should examine more upstream factors such as policy to improve food environments and access to fresh and nutritious foods. Future interventions should target recently arrived food-insecure Latino immigrants to prevent the onset of T2D as they have more duration in the United States by increasing accessibility, both the availability and affordability, to fresh vegetables and fruit. Finally, states and local policies can promote positive dietary consumption including increased intake of fresh vegetables and fruit through SNAP and other programs (that do not require citizenship as eligibility) by offering reimbursement and acceptance at local farmers' markets.[171–174] In order to decrease disparities in T2D-related morbidity, mortality, costs, and improve the overall quality of life among Latinos, future research should further examine the relationship between food insecurity and the disease process.

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