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Mapping food insecurity-related 2-1-1 calls in a 10-county area of Central Texas by zip code: exploring the role of geographic food access, urbanicity and demographic indicators

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Abstract

Introduction: Food insecurity is a public health issue that affects 12% of Americans. Individuals living in food insecure households are more likely to suffer from conditions such as undernutrition, obesity and chronic diseases. Food insecurity has been linked to limited geographic access to food; however, past studies have used limited measures of access which do not fully capture the nuances of community context. The purpose of this study was to explore the association between food insecurity and geographic food access by level of urbanicity.

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Methods: 2-1-1 calls made in 2018 in Central Texas were classified as food needs versus non-food needs. Supermarket and convenience stores were mapped using ArcGIS. Geographic food access was operationalized as the presence of supermarkets and convenience stores: within the zip code; only in neighboring zip codes; and not located within or in neighboring zip codes. Descriptive statistics and binomial logistic regression were used to examine associations between geographic access and 2-1-1 food calls, stratified by level of urbanicity.

Results: 11% of the 2-1-1 calls made in 2018 (N= 55,405) were regarding food needs. Results showed that peri-urban and rural callers living in zip codes that only had supermarkets in neighboring zip codes had greater odds of calling about food needs compared to those that had supermarkets within the zip code.

Discussion: These findings indicate that geographic food access is associated with food insecurity, but this relationship varies by urbanicity. Thus, the development of food insecurity mitigation programs in peri-urban and rural areas is needed.

Keywords

Geographic Food Access; Food Insecurity; 2-1-1 Calls; Urbanicity Disparities

INTRODUCTION

Food Insecurity: A Public Health Issue

Food insecurity is defined as the scarce or uncertain availability or the unstable ability to obtain culturally relevant, nutritious, and safe foods in socially acceptable ways (1). Although an industrialized nation, the United States has high rates of household food insecurity, with 11.8% of households identifying as food insecure in 2017 (2). Household food insecurity rates can also vary by state: Texas has a higher prevalence of food insecurity than the national average, with 14% of Texan families struggling with food insecurity from 2015–2017 (2).

These rates are startling and a public health concern, since food insecurity is associated with a variety of negative health outcomes (3–7). Specifically, food insecurity is associated with various conditions associated with undernutrition such as malnutrition, stunting and wasting, nutrient deficiencies and other conditions (3, 8, 9). Paradoxically, food insecurity is also associated with obesity and chronic disease occurrence, such as type 2 diabetes and hypertension (5, 7, 9–11). Thus, understanding and reducing domestic food insecurity is a critical public health concern.

Geographic Food Access and Indicators

Food insecurity conceptually is comprised of four components: availability, access, utilization, and stability over time (1, 12). Access is the most frequently researched component of food insecurity and refers to the geographic presence of culturally relevant, affordable, and safe-to-consume food within a community (12, 13). Geographic food access, meaning the physical availability of food retail in a community, is one of the most commonly discussed factors associated with food access and food insecurity in the literature (13–16).

Geographic food access has been researched domestically since the 1960's and several key demographic indicators and disparities have been noted in the literature (17–20). The most salient indicators in the literature are race/ethnicity, income, and urbanicity (17, 18, 20). People of color are less likely to have healthy food retail outlets in their communities and are more likely to have to travel longer distances to obtain health foods than non-Hispanic whites (20–22). Also, low-income communities are less likely to have supermarkets and more likely to have small grocery stores and convenience stores, which are linked to unhealthy choices, in their communities than higher income communities (19, 20, 23). Additionally, there are key disparities by urbanicity, with people living in rural areas having to travel farther distances to obtain food than their urban-living counterparts (17, 18, 24). Thus, these indicators need to be included in analysis and discussion on geographic food access.

Food Insecurity Resources and the United Way 2-1-1 Call Line

Connecting food insecure communities to resources such as food banks and food pantries, which are places that stocks of food that are supplied free of charge to people in need, are a critical resource for individuals who have emergency food insecurity (25–27). Nationally, the United Way has been connecting individuals in need to resources for over 50 years (28). In 2000, the Federal Communications Commission (FCC) developed a 2-1-1 hotline program to better facilitate network building and resource referrals for individuals in need (28). During the next decade, 2-1-1 hotlines became operational in all 50 states and Puerto Rico, and the 2-1-1 hotlines received more than 17 million calls in 2011 alone (28, 29). In 2011, roughly 40% of 2-1-1 call lines were operated solely by the United Way and the remaining 60% by a collaboration of various non-governmental organizations (28, 29).

Since its development, there has been a rich history of research and collaboration between 2-1-1 call lines, the United Way and researchers (29–33). Referrals by 2-1-1 have been shown to be effective at reaching historically hard-to-reach populations to promote service utilization as varied as enrolling in food assistance programs, to getting screened for human papilloma virus, finding affordable housing opportunities, promoting wellness check-ups and other services (29–33).

The 2-1-1 call line in the greater Austin area is operated by the United Way for Greater Austin and serves a 10-county area (34). In 2018 alone, the United Way for Greater Austin received over 50,000 2-1-1 calls and provided referrals to tens of thousands of organizations and services (34). Over 11% of calls to the United Way for Greater Austin 2-1-1 line were for food needs (34). The motivations for calling the 2-1-1 line for food insecurity related issues can range from a household member looking to find out more information about getting on food assistance programs such as Women, Infants and Children (WIC), or for more emergency-related needs like the location and hours of the nearest food bank. However, these data have yet to be mapped and assessed in Central Texas.

Research Objective and Hypotheses

Objective—The objective of this study was to examine the association between geographic food access and food insecurity and the demographic indicators of race/ethnicity, income,

and urbanicity. It was hypothesized that areas which do not have food retail located within or in neighboring zip codes will have more food need 2-1-1 calls compared to areas with high geographic food access. Additionally, that areas which do not have food retail located within or in neighboring zip codes will be areas with majority racial/ethnic minority populations and/or rural.

METHODS

Study Design and Study Area

The study design included cross-sectional analyses of 2018 United Way 2-1-1 Call Data. Participants were individuals who called the 2-1-1 call line from January 1 thru December 31, 2018. The sample was restricted to calls made to the United Way for Greater Austin in calendar year 2018 that stated a reason for calling and resided in one of the zip codes in the 10-county study area. Callers who reported living in a P.O. Box only zip code were dropped from the analysis (N = 300) since it was not clear which zip code those callers resided in. Demographic data from the 2017 American Community Survey (ACS), data about food retail obtained utilizing Google Places API and R, and ArcGIS were utilized to map these data (35, 36). Stata (version 14) was used for analysis (37). Because this study was a secondary data analyses, the IRB at UTHealth deemed this study exempt from IRB approval (HSC-SPH-19–1057).

Variables

Independent Variables—The independent variables for the analysis were various measures of geographic food access. Measures of geographic food access were developed by conducting density and polygon neighbor analysis of supermarkets and convenience stores located in each zip code of the 10-county area served by the United Way for Greater Austin 2-1-1 call line. Food retail layers were developed for the analysis. First, a fishnet was created in ArcGIS for the entire 10-county study area, and latitude and longitude coordinates of the study area were obtained (35). These coordinates were used to find the addresses of all supermarkets/grocery stores and convenience stores present in the study area through R (googleway package) and Google Places API. These addresses were subsequently geocoded utilizing ArcGIS and created two different layers, one with supermarket/grocery store locations, and one with all convenience store locations in the study area (35).

A series of variables were created to determine the presence of supermarkets/grocery stores and convenience stores by zip code. A spatial join was utilized to attribute the locations of food retail by type to each zip code. Once completed, the polygon neighbors tool was utilized in ArcGIS to determine the presence of food retail in neighboring zip codes (35). These attribute tables were exported as an Excel file and then to Stata (37), where three binary variables were developed that defined geographic food access in each zip code: zip codes that had food retail present within the zip code; zip codes that did not have food retail present in the zip code and only had food retail present in neighboring zip codes; and zip codes that did not have food retail present within or in neighboring zip codes.

Dependent Variables—The dependent variable for this analysis was food insecurity. Food insecurity was operationalized using the proxy of the food need calls to the United Way operated 2-1-1 call line in 2018. Specifically, 2-1-1 calls were categorized based upon the resources that the caller requested more information about during the call with the 2-1-1 call navigator into two groups. Calls were categorized into food needs (looking for food pantries, soup kitchens, food banks, food assistance, etc.), and non-food related (information about housing or transportation but not about food) calls.

Community-Level Indicators—As previously mentioned, race/ethnicity, income and urbanicity have been shown in past research to be significant indicators of geographic food insecurity and were thus included in the analyses (17, 18, 20). Race/ethnicity, income level, and urbanicity of the caller were not included in the data provided by the United Way, although the zip code of the caller was included in all calls. The 2017 ACS data set included race/ethnicity and household income categorized by zip code. Therefore, race/ethnicity was assigned based on the majority race/ethnicity of that zip code according to the 2017 ACS. Due to distribution, this then became a binary variable defined as majority non-Hispanic white population or majority racial/ethnic minority population.

Income was operationalized as a percent of the population in the zip code living below the poverty line according to the 2017 ACS. Urbanicity was determined based upon the Census definition and US Department of Defense definition of urban areas based on population density for each zip code (18, 24, 38). Zip codes with a population density over 3,000 people per square mile were categorized as urban, zip codes with a population density between 1,000 and 3,000 people per square mile were categorized as peri-urban, and zip codes with a population density of less than 1,000 people per square mile were categorized as rural (38).

Potential Covariates—While race/ethnicity, income, and urbanicity are crucial indicators, they are not the only potential covariates. Other potential covariates included employment status and utilization of food assistance programs and were measured at the zip code level. Employment status was operationalized as percent of population of the zip code over the age of 16 that were unemployed according to the 2017 ACS. Utilization of food assistance was operationalized as the percent of households utilizing the Supplemental Nutrition Assistance Program (SNAP) in the zip code according to the 2017 ACS.

Analyses

Statistical analyses were performed utilizing Stata version 14 and ArcGIS (35, 37). Descriptive statistics are presented in two tables for call-level data, and zip code level data respectively. Descriptive statistics included frequencies and percentages calculated for each categorical variable and indicator. Mean and standard deviations were calculated for each continuous variable and the range provided. Dependent variables were assessed for normality using the Shapiro-Wilk test and visually. Distributions of categorical variables were examined for the potential need to collapse across categories. Logistic regression models were conducted to observe the association between geographic food access and food need calls and demographic indicators. Model I contained the unadjusted associations between geographic food access, food need calls, and the potential moderators of race/

ethnicity and urbanicity. Model II included the variables discussed in Model I and introduced income, as operationalized as percent below poverty by zip code, and potential covariates such as percent unemployment and percent of households on SNAP. Tests for interactions between race/ethnicity, urbanicity and geographic food access variables were also conducted.

RESULTS

Descriptive Statistics and Sample

The final sample consisted of 55,405 calls from 120 zip codes in the 10-county study area. An intraclass correlation coefficient (ICC) was calculated to quantify clustering by zip code; calculated ICC = 0.011); was negligible, thus, multi-level analyses were not needed. Descriptive analyses for call-level data are presented in Table 1. The average age of callers was approximately 45 years old, and the majority of callers were women (72.53%). Nearly 73% of calls were from one county (i.e. Travis County), despite the hotline serving a 10-county area, and over half of the callers reported living in zip codes that were classified as urban. Over 11% of calls to the United Way for Greater Austin's 2-1-1 line were food need. Figure 1 depicts the percentage of food need calls by zip code. In 2018, 10–20% of calls were regarding food needs in almost half (N=59) of the zip codes in the study area. Approximately 9% (N=11) of the zip codes had no food need calls to the United Way in 2018.

Descriptive analyses for zip code level data are presented in Table 2. Most zip codes in the sample had a population that was majority non-Hispanic white. Almost 20% of the zip codes were classified as urban based on the population density of the zip code, with 12.50% of zip codes classified as peri-urban and over 68% of zip codes classified as rural. The average percentage of population living below the poverty line was 11.50%. The average percentage of the population over the age of 16 that was unemployed was 4.30%. In the study area, there was an average of 8.21% of households on SNAP. Of the 120 zip codes in the study area that received calls, 60% of them had a supermarket or grocery store within the zip code, and over 36% had a supermarket or grocery store only in neighboring zip codes. All zip codes in the sample had a convenience store within or in neighboring zip codes, and 85% of zip codes had a convenience store within the zip code. The presence of food retail by zip codes were also mapped and presented in Figure 2 and Figure 3.

Logistic Regression Results

Models from the Full Sample—Logistic regression models were conducted to examine the associations between geographic food access and food need calls and demographic indicators. Table 3 displays the results of the logistic regression models in terms of odds ratios, 95% confidence intervals, and *p*-values for the full sample. Model I contains the unadjusted associations between geographic food access, emergency food need calls, and the potential moderators of race/ethnicity and urbanicity. Results from the unadjusted model found that callers living in peri-urban (OR = 0.88, $p<0.01$) and rural (OR = 0.82, $p<0.01$) zip codes had statistically significant lower odds of calling the United Way 2-1-1 line about a food need than those living in urban zip codes; however, the geographic food access

variables had no statistically significant associations on food need calls. Model II included the variables discussed in Model I and introduced income, unemployment, and household utilization of SNAP.

Results from the adjusted model were consistent with results from the unadjusted model that callers living in peri-urban (OR=0.89, $p<0.01$) and rural (OR=0.81, $p<0.01$) zip codes had statistically significant lower odds of calling the United Way 2-1-1 line about a food need than those living in urban zip codes, and geographic food access variables had no statistically significant associations on food need calls. Additionally, analyses from the adjusted model found that those living in zip codes with greater percentage of households using SNAP had slightly lower odds (OR = 0.99, $p<0.01$) of making a food need call than those with lower percentage of households using SNAP. Results from the adjusted model also indicated that individuals living in areas with high percentages of the population living in poverty (OR = 1.01, $p<0.01$), and areas with higher prevalence of unemployment (OR = 1.03, $p<0.01$) had slightly greater odds of calling with a food need than those living in zip codes with lower percentages of the population living in poverty and unemployed. Race/ethnicity variables were not statistically significant in either model. Tests for interactions between race/ethnicity and urbanicity and the geographic food access variables were conducted. There were no statistically significant interactions between race/ethnicity and geographic food access. However, there were statistically significant interactions between urbanicity and geographic food access, which required stratified analyses by urbanicity.

Stratified Results: Urban—All callers living in urban zip codes lived in a zip code that had a supermarket and convenience store, therefore, there was collinearity and the geographic access variables could not be analyzed for callers from urban zip codes. However, there were statistically significant associations between covariates and food need calls among callers from urban zip codes. Among urban callers, residents of a zip code that were majority racial/ethnic minorities, had lower odds of making a food need call (OR = 0.88, $p<0.01$) than those that lived in majority non-Hispanic white and urban zip codes. Also, unlike the full sample adjusted analyses, urban callers that lived in zip codes with higher percentages of unemployment had lower odds to call with a food need (OR = 0.91, $p<0.01$) than those who lived in zip codes with lower percentages of unemployment. Consistent with findings from the full sample, among urban callers, those living in zip codes with higher percentages of the population living below the poverty line had greater odds (OR = 1.02, $p<0.01$) for calling with food needs than those that lived in zip codes with lower percentages of the population living below the poverty line.

Stratified Results: Peri-Urban—In the unadjusted model, callers from peri-urban areas that only had supermarkets in neighboring zip codes had lower odds (OR = 0.64, $p<0.01$) of calling with a food need in 2018, however once covariates were included in the model, they had 2.59 greater odds ($p<0.01$) of calling with a food need than their counterparts with a supermarket in their peri-urban zip code. In the adjusted models, living in peri-urban zip codes with higher percentages of people living below poverty (OR = 1.11, $p<0.01$) and unemployment (OR = 1.48, $p<0.01$) had greater odds of calling with a food need than those that lived in peri-urban zip codes with lower percentages of people living below poverty

and unemployment. Also, callers living in zip codes with higher percentages of households utilizing SNAP had lower odds (OR = 0.83, $p<0.01$) of calling with a food need than those living in peri-urban zip codes with lower percentages of households utilizing SNAP. Race/ethnicity variables were not significant for callers from peri-urban areas.

Stratified Results: Rural—In the adjusted model callers from rural zip codes that only had supermarkets/grocery store in neighboring zip codes had 1.23 greater odds ($p<0.05$) of calling with a food need than those living in rural zip codes with a supermarket/grocery store. Presence of convenience stores, percentage of population below poverty and unemployed were not significant for rural callers but were significant in all other strata of urbanicity.

DISCUSSION

Overall Findings

The findings from the descriptive statistics and logistic regression models indicated that there were food needs in Central Texas among callers to the United Way for Greater Austin's 2-1-1 line in 2018, and that these food needs differed according to urbanicity. Additionally, the presence of an interaction between urbanicity and geographic food access variables indicate that there were unique complexities to the relation between geographic food access and food insecurity across urbanicity levels. Living within a zip code that only had supermarkets/grocery stores in neighboring zip codes led to greater odds of calling the United Way for a food need in peri-urban (OR = 2.59, $p<0.01$) and rural (OR = 1.23, $p<0.05$) areas compared to those that lived in zip codes with a supermarket/grocery store within peri-urban and rural areas, respectively. Geographic food access is an important indicator for food need calls, and consequently, to food insecurity among peri-urban and rural communities.

These findings are consistent with the limited literature in this area. Geographic food access literature has found that rural areas have limited geographic food access (17, 18, 24, 39–41). Also, while there have been some studies exploring the role of geographic food access in rural communities, there has been little exploration as to how low geographic food access contributes to food insecurity among rural communities domestically (39, 40, 42). However, the findings from this research that limited geographic access contributes to food insecurity is consistent with other studies (39, 40, 42). Additionally, while peri-urban areas have been a source of international research and domestic agricultural research, there has been very little research investigating how Americans in peri-urban areas experience geographic food access or food insecurity (9, 43–46). Thus, these analyses fill a notable gap in the literature.

Another key finding from this analysis is the distribution of calls from urban, peri-urban, and rural areas. Over half of the calls to 2-1-1 were from urban zip codes, and 75% of calls were from Travis County, the county where Austin is located in. These findings imply that there could be greater awareness of the 2-1-1 call line in areas closest to Austin and in more densely populated areas. Moreover, the initial hypotheses that calls from areas with the most limited geographic food access (those that did not have supermarkets within or in neighboring zip codes) were not more likely to be food need calls than those that had

food retail located within the zip code. This could also be because individuals in areas with the most limited access are used to having to travel further distances for any service, including food services (24, 40). However, areas that had more peripheral access, calls from areas that only had supermarkets in neighboring (but not within) zip codes in peri-urban and rural areas were more likely to be food need calls, which demonstrate that areas with somewhat limited access were more likely to have food need calls. This finding alludes to the possibility of the suburbanization of poverty occurring in Austin (47). Thus, that as Austin has gotten more expensive to live in during the last decade, that low-income individuals are moving into more peri-urban areas with limited food access resources.

Furthermore, different covariates of race/ethnicity, percentage of population below poverty, population over the age of 16 that were unemployed, and household utilization of SNAP had different statistically significant associations in different environments. For instance, living in a majority racial/ethnic minority zip code meant urban callers had lower odds about calling for a food need (OR = 0.88), which contradicts the literature, but was a factor that had greater odds for rural callers to call about a food need (OR = 1.17), which is consistent with the literature (20–22). Further emphasizing that these relations exist differently in different localities, these findings confirm that place matters even within a 10-county region. Thus, further research is needed to explore the association between race/ethnicity, income, unemployment, and food assistance programs and food insecurity across different urbanicity levels.

Strengths and Limitations

Strengths—This study has numerous strengths. Previous studies typically have only utilized census data with food retail to explore the association between geographic food access and food insecurity and have not incorporate additional data sources that present confirmed need, such as 2-1-1 call data. Furthermore, the large sample size of the 2-1-1 call data from the United Way for Greater Austin (N = 55,405) enabled analyses that were not previously possible with smaller cohorts with insufficient power. Additionally, most of the previous literature presents findings from only one municipality or a one or two county area (15, 48). However, this study analyzed data at a zip code level for the entire 10-county Central Texas region. Thus, this study can help researchers and regional planners better understand geographic food access and food insecurity at a regional level. Furthermore, the majority of geographic food access literature is solely focused on either an urban or a rural area, and does not take into account the unique experiences of those living in peri-urban areas (17, 18, 24, 40, 49). By including urban, peri-urban, and rural areas of Central Texas and stratifying analyses, this study provides valuable insight into the association between food insecurity and geographic food access across urban strata within a region.

Limitations—However, there are notable limitations in this study. Measuring geographic food access at the zip code level can be helpful for understanding community context and community geographic food access, but it is not as precise a measurement of geographic food access as utilizing individual-level data. While this study utilizes multiple sources of data, it has limited individual-measured data, thus future studies are needed to better measure proximity of individuals to food retail. Future analysis could also explore looking at

calls during specific seasons in order to have a more nuanced understanding of the potential seasonality of food need calls, which is not currently captured in this analysis of annual calls in the Central Texas region.

Additionally, there is potential for threats to validity with this sample, specifically selection bias and limited generalizability. Since inclusion in this sample required that an individual called 2-1-1 operated by the United Way for Greater Austin, this sample is most likely predominantly low-income and requires awareness of the 2-1-1 program. As previously mentioned, findings from the full sample could indicate that there is potentially limited awareness of the 2-1-1 call line in rural and peri-urban areas of the 10-county area served by the United Way for Greater Austin, thus resulting in selection bias. Furthermore, this sample may not be representative of the overall 10-county area since callers are most likely low-income. Thus, future studies should explore utilizing a more representative sample in order to minimize selection bias and offer greater generalizability.

Despite these limitations, these analyses contribute valuable insight into the geographic food access and food insecurity literature. Additionally, the analyses provide maps and other outputs that will serve as tangible resources to give the United Way for Greater Austin, the City of Austin, food insecurity non-profit organizations, and researchers to better develop programming and distribute resources to areas with limited geographic food access in the Central Texas region.

Recommendations and Future Research

Due to the unique differences in the association between geographic food access and food need calls by urbanicity, future research should be mindful of comparing across urban strata. Thus, urbanicity should be taken into account when investigating associations between geographic food access and food insecurity in areas that are not strictly urban, peri-urban, or rural. Additionally, future research could investigate more factors of the food retail environment, such as non-traditional food retail and emergency food need resources. Also, further investigation regarding the built environment such as connectivity and public transportation could provide greater insight into the other additional factors facilitating or impeding geographic food access. Thus, greater research is needed in order to gain a more nuanced understanding of how geographic food access and food insecurity are related in a variety of contexts.

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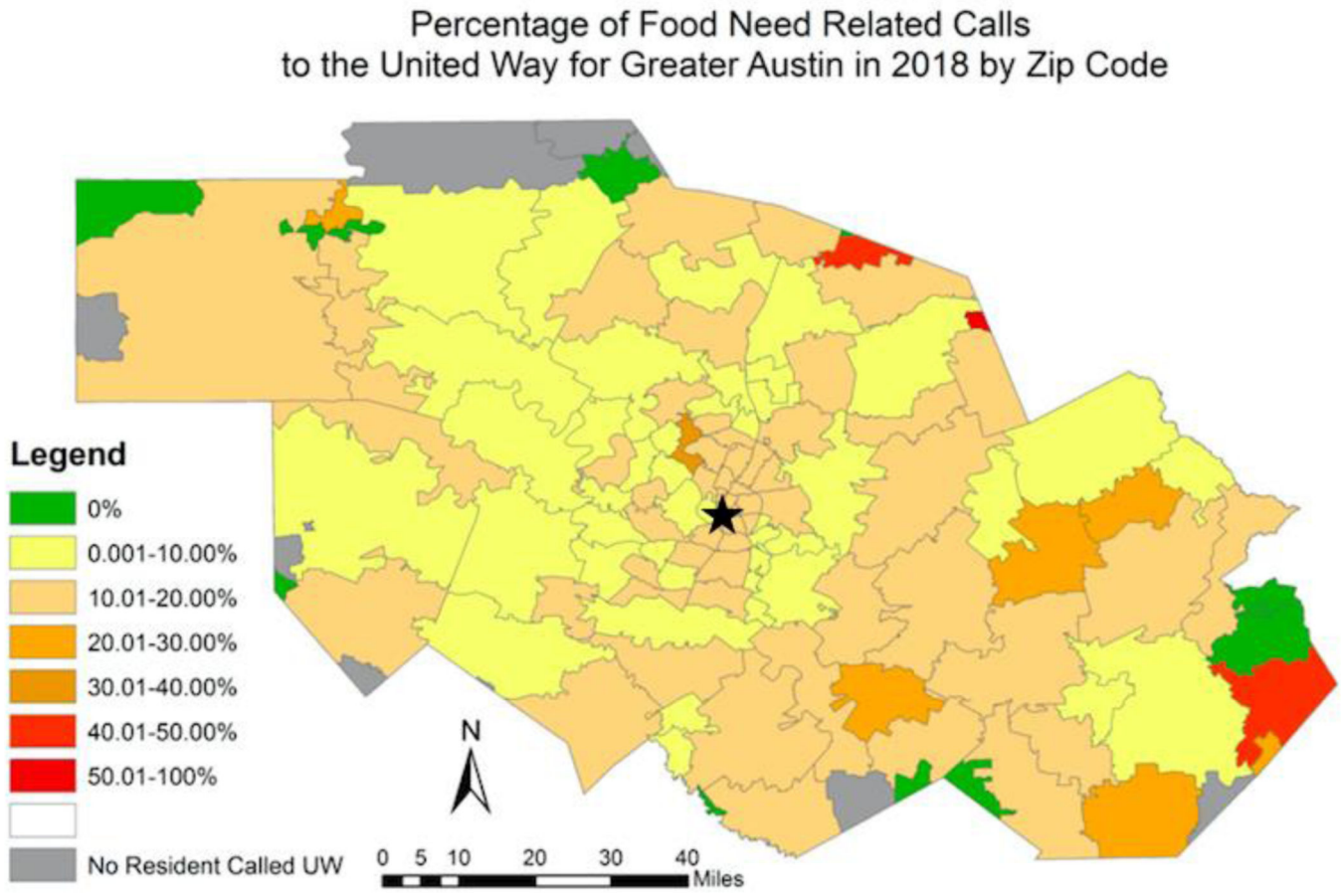

Figure 1:
Percentage of Food need Calls to the United Way for Greater Austin 2-1-1 Line in 2018 by Zip Code in a 10 County Area

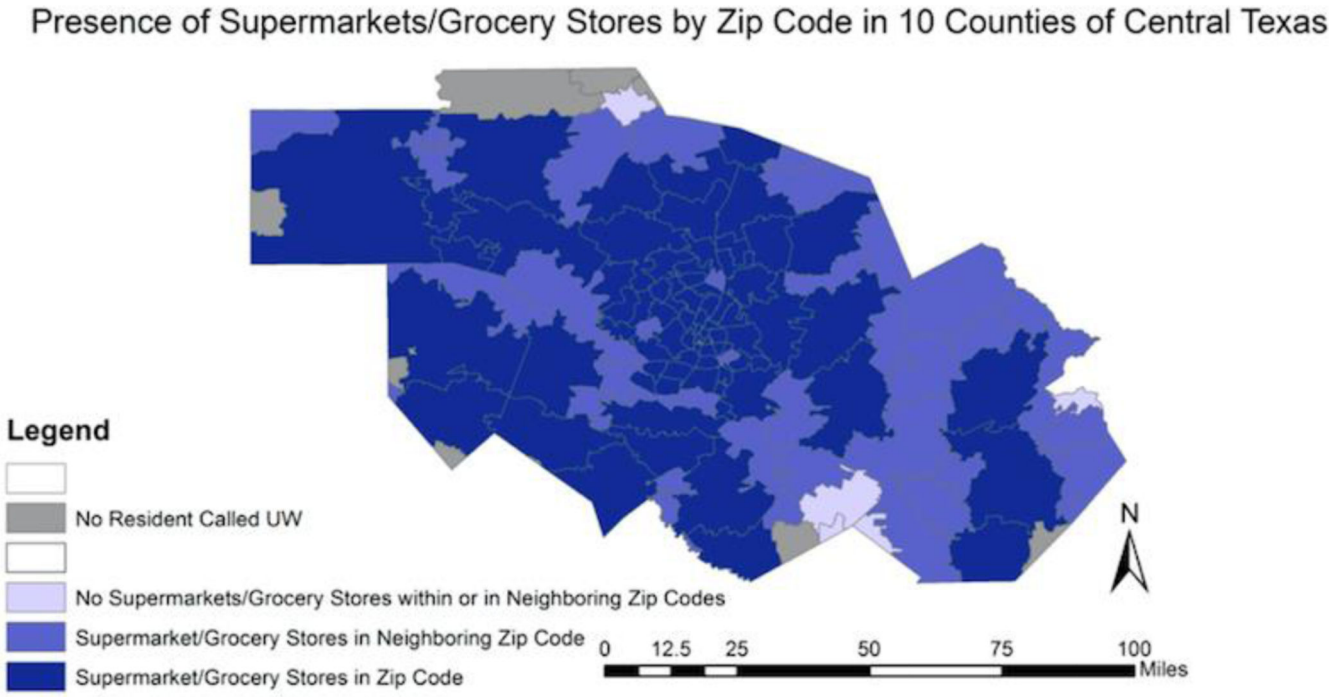

Figure 2:

Presence of Supermarkets/Grocery Stores by Zip Code in United Way for Greater Austin 2-1-1 10-County Service Area (Blue Map)

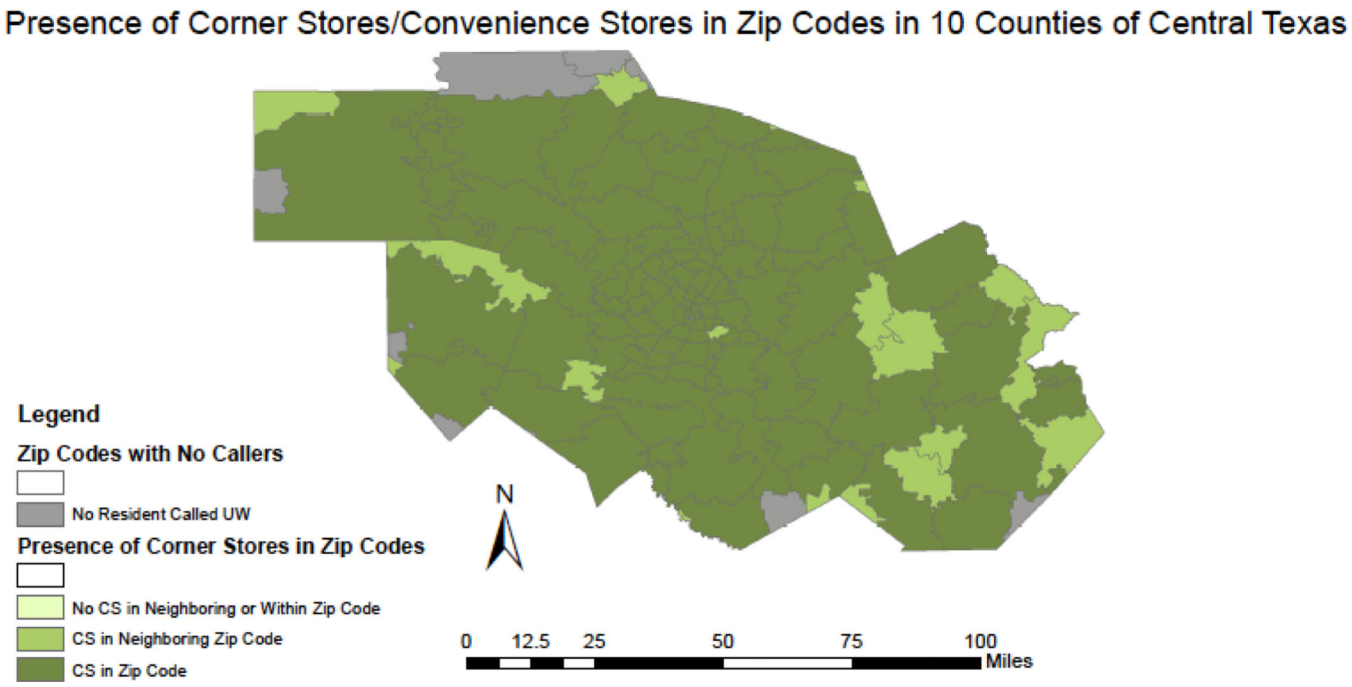

Figure 3:
Presence of Convenience Stores by Zip Code in United Way for Greater Austin 2-1-1 Line 10-County Service Area (Green Map)

Table 1:

Descriptive Statistics of 2-1-1 Call-Level Data

Variable	N = 55405	Frequency (%)	Mean (SD)
Demographics			
Age (years)	52,087		45.32 (SD = 16.68)
Gender			
Male	14,805	26.74	
Female	40,164	72.53	
Uncertain	407	0.73	
County of Caller			
Bastrop	1,991	3.59	
Blanco	86	0.16	
Burnet	608	1.1	
Caldwell	871	1.57	
Fayette	358	0.65	
Hays	2,801	5.06	
Lee	195	0.35	
Llano	384	0.69	
Travis	40,255	72.66	
Williamson	7,856	14.18	
Urbanicity of Zip Code of Caller			
Urban (Population Density>3,000 people per mile^2)	28,467	51.38	
Peri-Urban (1,000–3,000 people per mile^2)	12,622	22.78	
Rural (Under 1,000 people per mile^2)	14,316	25.84	
Food Insecurity			
Food Insecurity Related Calls			
Food Related Need Calls	6,310	11.39	
Non-Food/At-Risk Calls	49,095	88.61	

Table 2:

Descriptive Statistics of Zip Code Level Data

Variable	N = 120	Frequency (%)	Mean (SD [Range])
Demographic Indicator Variables			
Race/Ethnicity			
Majority Racial/Ethnic Minority Zip Code (>50% of population identifies as a racial/ethnic minority)	15	12.5	
Majority Non-Hispanic White Zip Code (>50%)	105	87.5	
Urbanicity			
Urban (Population Density>3,000 people/mi^2)	23	19.17	
Peri-Urban (1,000–3,000 people/mi^2)	15	12.5	
Rural (<1,000 people/mi^2)	82	68.33	
Additional Potential Covariates			
Percentage of Population Living Below Poverty Line			
Average Percent of People Living Below Poverty Line			11.50% (SD = 8.31, [0–63])
Percentage of Unemployed			
Average Percent of People (Over the age of 16) Unemployed			4.30% (SD = 3.00, [0–23.3])
Percentage of Households on SNAP			
Average Percent of Households on SNAP			8.21% (SD=7.57, [0–55.6])
Geographic Food Access Variables			
Presence of Supermarket/Large Grocery Store			
Access within zip code	72	60	
Access in neighboring zip codes	44	36.67	
No access within or in neighboring zip codes	4	3.33	
Presence of Convenience Store			
Access within zip code	102	85	
Access in neighboring zip codes	18	15	
No access within or in neighboring zip codes	0	0	

Table 3:

Logistic regression models measuring association between geographic food access and food need 2-1-1 calls and indicators/covariates

Full Sample N = 55,405			**Urban N = 28,467**	**Peri-Urban N = 12,622**		**Rural N = 14,316**	
	Model I (unadjusted) (Food Need Related Calls)	**Model II (Food Need Related Calls)**	**Model I (Food Need Related Calls)**	**Model I (unadjusted) (Food Need Related Calls)**	**Model II (Food Need Related Calls)**	**Model I (unadjusted) (Food Need Related Calls)**	**Model II (Food Need Related Calls)**
Variable (reference category for categorical variables)	**OR [CI]**	**OR [CI]**	**OR (CI)**	**OR (CI)**	**OR (CI)**	**OR (CI)**	**OR (CI)**
Variables Introduced in Model I							
Presence of Supermarket/Large Grocery Store (Referent = Access within zip code)							
Access only in neighboring zip codes	1.00 [0.88–1.12]	1.04 [0.92–1.18]	-	**0.64 **[0.51–0.78]**	**2.59 **[1.74–3.85]**	**1.23 **[1.06–1.42]**	**1.21 *[1.04–1.41]**
No access within or in neighboring zip codes	0.92 [0.28–3.07]	1.03 [0.31–3.44]	-	-	-	1.00 [0.30–3.34]	1.03 [0.31–3.47]
Presence of Convenience Store (Referent = Access within zip code)							
Access only in neighboring zip codes	1.17 [0.80–1.72]	1.28 [0.87–1.88]	-	-	-	1.05 [0.71–1.55]	1.12 [0.75–1.68]
Race/Ethnicity (Referent = Majority Non-Hispanic White Zip Codes)							
Majority Racial/Ethnic Minority Zip Codes	1.02 [0.97–1.09]	1.04 [0.97–1.13]	**0.88 **[0.80–0.96]**	0.91 [0.80–1.02]	2.16 [0.83–5.61]	1.06 [0.93–1.20]	1.17 [0.99–1.39]
Urban/Rural Status (Referent = Urban Area)							
Peri-Urban(Between 1,000–3,000 people/square mile)	**0.88 **[0.82–0.94]**	**0.89 **[0.83–0.96]**	-	-	-	-	-
Rural (<1,000 people/ square mile)	**0.82 **[0.77–0.88]**	**0.81 **[0.75–0.87]**	-	-	-	-	-
Variables Introduced in Model II							
Low-Income							

Full Sample N = 55,405			Urban N = 28,467	Peri-Urban N = 12,622		Rural N = 14,316	
	Model I (unadjusted) (Food Need Related Calls)	Model II (Food Need Related Calls)	Model I (Food Need Related Calls)	Model I (unadjusted) (Food Need Related Calls)	Model II (Food Need Related Calls)	Model I (unadjusted) (Food Need Related Calls)	Model II (Food Need Related Calls)
Variable (reference category for categorical variables)	**OR [CI]**	**OR [CI]**	**OR (CI)**	**OR (CI)**	**OR (CI)**	**OR (CI)**	**OR (CI)**
Percentage of Population Living Below Poverty Line	-	**1.01 **[1.00–1.01]**	**1.02 **[1.01–1.03]**	-	**1.11 **[1.04–1.19]**	-	1.00 [0.99–1.01]
Unemployment							
Percentage of Unemployed Population Over Age 16	-	**1.03 **[1.01–1.05]**	**0.91 **[0.88–0.95]**	-	**1.48 **[1.37–1.61]**	-	1.02 [0.99–1.06]
SNAP Participation							
Percentage of Households on SNAP	-	**0.99 **[0.98–0.99]**	1.00 [0.99–1.01]	-	**0.83 **[0.80–0.87]**	-	0.99 [0.97–1.00]

* $p < 0.05$

** $p < 0.01$

- not included in model due to collinearity, stratification, or due to the model