

Exploring Rural Food Insecurity in North Carolina: Debunking an Urban Myth*

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Abstract

The United States Department of Agriculture (USDA) has utilized the term food desert to highlight regions within low-income communities located far from fresh and healthy sources of food such as supermarkets and farmers markets. Most research on food deserts has revolved around urban areas, which bring about other considerations such as sidewalks, pedestrian access, rideshares, and public transportation, typically not viable options in rural regions. Rural food insecurity is also a problem in North Carolina. Utilizing data provided by the United States Department of Agriculture's Food Access Atlas, this paper explored if and to what extent rural food insecurity exists, with findings showing 1) a higher percentage of people living in rural areas live in food insecurity compared to non-rural areas 2) counties in the eastern part of the state are more prone to food insecurity and 3) racial, ethnic minorities, as well as the young (age under 17), are more subjected to food insecurity compared to the majority and older cohorts. This research highlights the need for a rigorous and comprehensive understanding of rural food security that transcends the economic, cultural, and sociological reasons of differential food access with long-term health outcomes that have multi-generational consequences.

Keywords: Food access, Food desert, Food insecurity, Rural food insecurity, USDA data

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Introduction

In North Carolina, food security is an unrelenting and pressing concern. Before the pandemic, North Carolina had the eleventh highest child food insecurity rate at 19.3% (Feeding America 2020) and above-average overall household food insecurity (Coleman-Jensen 2019). While global and national scale food security concerns itself with hunger, famine, food production, food distribution chains, and commodity prices (Rodriguez 2008), local food security ensures one's ability to have easy and affordable access to healthy food.

The United States Department of Agriculture (USDA) has utilized the term food desert to highlight

regions within low-income communities far from fresh and healthy food, such as supermarkets and farmers markets. People living in food deserts are described as food insecure or in a state of food insecurity. Research by Moore et al. (2008), Austin et al. (2005), Chen and Clark (2013), Block et al. (2004), and Zenk and Powell (2008) highlighted food security research in larger urban areas such as New York, Pittsburgh, Columbus, Chicago, and Detroit, respectively. Research in cities such as Durham (Rummo et al. 2015) and Lawrence (Hallet and McDermott 2011) highlight work in moderately-sized cities such as those seen in North Carolina. Furthermore, the dynamics of food security are changing. As smaller food retailers are closing, the

number of large retailers is consolidating but increasing in size to accommodate all grocery and non-grocery shoppers (Clarke et al. 2009). As these retailers and big box stores that serve as sources of healthy food are migrating to the suburbs from downtowns (Furey et al. 2001) and these retailers tend to locate near high-volume roads, these food sources are less accessible to non-vehicular individualized transportation more prevalent in urban areas (i.e., walking, public transit or riding a bike) (Mamen 2007).

Figure 1: Sign Outside of Vacant Grocery Store in Gibsonville, Guilford County, North Carolina



Contemporary research on food insecurity has primarily focused on urban food deserts, such as those in Greensboro along the East Market Street corridor (Killian 2019) or the Durham-Chapel Hill region (Parsons 2012); however, rural food insecurity is indeed a problem, as shown in Figure 1 for Guilford County and across North Carolina as well. In particular, rural areas in North Carolina are unique because they can be hard to define (sometimes they are defined as to what they are not) and include regions and counties with diverse and distinctive racial and ethnic makeups. For example, rural counties in North Carolina include majority-minority counties such as Bertie County in the northeast that have a higher percentage of African American residents than White residents, largely homogeneous counties in the mountains, counties such as Duplin County where almost ¼ of all residents are Hispanic and counties such as Swain and Robeson Counties which have significant American Indian populations. Nonetheless, the general theme in much of the food desert literature

explores differential access to healthy and unhealthy food along economic and racial lines in urban areas.

Studying the food environment requires qualitative methods, quantitative calculations, and mixed methods, which analyze qualitative and quantitative data within the same study. Recent works have been trending in this direction (Shannon 2015, Chrisinger 2016, Brindle-Fitzpatrick 2015) since they also consider individual perceptions and descriptions of one's food environment that can not be represented using data agglomerated within enumerations units such as census tracts as this study has done.

Given these varying dynamics, measurements scales, and the understanding that rural food insecurity is a pervasive yet understudied problem that requires a multi-faceted approach, this paper will explore 1) if rural food insecurity is a problem in North Carolina compared to urban food insecurity 2) if rural food insecurity does exist, where does it exist in North Carolina and 3) what ages, races, and ethnicities may be impacted most by rural food insecurity. After a brief survey of the literature on food security, research will utilize empirical data provided by the USDA Food Access Atlas that contains information about income, food availability, and related socio-economic factors such as age, race, and ethnicity collected at the census tract scale. While the USDA and census collect individual-level data, access to these individual-level data is restricted and difficult to procure. This research highlights the need for a rigorous and comprehensive understanding of rural food security that transcends the economic, cultural, and sociological reasons of differential food access with long-term health outcomes that have multi-generational consequences.

Theoretical & Empirical Framework

Most research on food insecurity has revolved around urban areas, which bring about other considerations such as sidewalks, pedestrian access, rideshares, and public transportation, which are typically not viable options in rural regions despite an increasing understanding that rural communities are also disproportionately affected by unhealthy food environments (Morton and Blanchard 2007). In addition, obesity and chronic disease rates are rising among rural residents (Centers for Disease Control and Prevention 2016, Befort et al. 2021, Okobi et al. 2021), as the adult obesity rate for metropolitan counties was 28.7%, compared to 34.2% for non-metropolitan counties. The fact that a majority of residents do not meet fruit and vegetable intake recommendations due in part to disparities in food access in rural communities (Morland et al. 2002, Morton et al. 2005) underscores the need for a more

holistic look at the rural food environment (Hubley 2009, Van Hoesen et al. 2013, McEntee and Agyemem 2010).

Research by Lewis et al. (2005) highlighted distinct disparity when unhealthy food options greatly outweighed healthy counterparts in urban Los Angeles. Other research found low-income and minority neighborhoods had less healthy food selection than their richer and whiter counterparts (Powell et al. 2007). Zenk (2005) found that urban regions that were more impoverished and had a higher percentage of African American residents were located further from supermarkets than regions that were less impoverished and had fewer African Americans. When these large retailers migrate to the suburbs, typical fresh and healthy food sources are being replaced by fast food restaurants and convenience stores that offer food options that are convenient (easily prepared and physically closer) and inexpensive but typically less healthy. Because of this shift, the long-term ramifications on community health have yet to be seen but should be easy to predict.

While relatively older, an assessment of food desert literature by Walker et al. (2010) further highlighted the focus on urban food security. Their paper explored 71 different publications that utilized different techniques to measure food security. They included measurements of distance (distance to the nearest grocery store, such as this paper), food variety (the number of different types of food within a ZIP code, for example), and cost (comparison of the cost of food in different parts of the country). Only ten (10) of these papers were focused on rural food security. Findings focusing on rural food security included food was perceived to be less affordable compared to suburban counterparts (Hendrickson et al. 2006), poorer residents of rural areas relied more on convenience stores for food (Kaufman 1999), and food outlets were more prevalent in urban areas compared to rural areas (Powell et al. 2007). None of these studies were focused on North Carolina. Still, other works by Towns and Moye (2020), in addition to the results mentioned above by Rummo et al. (2015) and Parsons (2012), focus explicitly on North Carolina. All primarily focus on urban regions. However, a work by Mulrooney et al. (2017) focused explicitly on rural deserts in an 11-county region in southeastern North Carolina, with results highlighting food swamps (regions with inordinately higher access to unhealthy food options compared to healthy food options) highlighted statistical differences between food swamps and counterparts along racial and economic lines. Miller et al. (2015) reinforced this notion in another GIS-based work around Topeka, Kansas. Work by Paul et al. (2019), based on work in Durham, North Carolina, noted that minority populations have

more compromised access to healthy food and explored the social institutions at local scales that can change these patterns. Leddy et al. (2020) explore this idea of social capital in managing food insecurity among older women in the United States. Literature by Whitley (2013), Holston et al. (2020), and Hossfield and Rico (2018) underscore rural food insecurity has been difficult to wholly understand despite perceptions to the contrary, such as the fact the cost of living is lower in rural regions. Food should be easier to procure since rural residents live closer to agricultural areas where food is produced.

Methods

Data

In an attempt to explore if and how quantitative differences between rural and non-rural food access across various cohorts in North Carolina, empirical data provided by the USDA Food Access Atlas (<https://www.ers.usda.gov/data-products/food-access-research-atlas/download-the-data/>) contains information about income, food availability, and related socio-economic factors such as age, race, and ethnicity in a spreadsheet format. These data serve as the backbone of the USDA Food Access Mapping application (<https://www.ers.usda.gov/data-products/food-access-research-atlas/go-to-the-atlas/>), which maps food access and associated metrics. Data are collected at the census tract level. Tracts are subdivisions of counties. Exploring only those census tracts located in North Carolina results in 2,184 census tracts within all 100 North Carolina's counties whose population averages about 4,499 people and size averages 24.78 square miles. In urban regions where population densities are much higher, population numbers generally remain consistent, but the size of census tracts is much smaller. For example, in Guilford County, which contains the city of Greensboro, 119 census tracts have an average population of 4,104 and an average of 5.52 square miles in size.

Also included in these data is a flag (1 = yes, 0 = no) to denote if a census tract is urban. This flag can be problematic because census tracts that are not urban should not be automatically considered rural. Using Guilford County as an example, there are 19 census tracts not denoted as urban in Guilford County, even though Guilford County primarily contains urban and suburban areas. However, these 19 non-urban census tracts are much different than truly rural regions. For example, in these 19 census tracts, only 2.807% of households do not have access to a vehicle, compared to 8.669% of households that do not have access to a vehicle in rural Sampson County. Distinct differences

between cohorts of non-urban who may be either suburban or rural create vastly different dynamics for those rural populations who may be represented as food-needy and those who are genuinely food-needy.

There is a continuum of urban to rural. There are several different standards or organizations to determine if an enumeration unit (county, ZIP code, census tract, etc.) is urban, rural, or somewhere in between based on quantitative measures based on population, population density, and size cities and commuting patterns. One of the most basic examples is the Metropolitan Statistical Area (MSA) developed by the Office of Management and Budget (OMB), which is a county-level designation of metropolitan, micropolitan, or rural (neither metropolitan nor micropolitan). While it has its shortcomings, this classification recognizes micropolitan counties as buffers between rural and metropolitan counties like Mecklenburg, Wake, Guilford, and Forsyth Counties. Examples of micropolitan counties in North Carolina include Pitt (home of Greenville), Watauga (Boone), and Robeson (Lumberton) Counties. Utilizing data provided by the United States Census (United States Census 2019), all census tracts in metropolitan counties (have at least one urban area > 50,000 population, n = 40) were denoted as metropolitan, all census tracts located in micropolitan counties (have at least one urban area between 10,000 and 50,000 population, n = 27) were designated as micropolitan. All remaining census tracts were denoted as rural (n = 33).

Also included in these data are flags for 'Low Access.' According to the USDA, low access is defined as regions that are either 1 mile from a supermarket in an urban area or 10 miles from a supermarket in a rural area. Other attributes include flags for food deserts (Low Access and Low Income), the county name in which the census tract is located, income, poverty rate, living quarters (% living in group quarters) as well as both raw numbers and percentages of ages, race, and ethnicity collected by the census.

Data Collection

Utilizing an ecological model in which factors related to the physical access to healthy food options and socio-economics can explain the food environment, data related to these factors can be extracted from the USDA Food Access Atlas (ERS 2019b). Of the 148 attributes provided by the USDA Food Access Atlas data (ERS 2019b), only about a dozen were necessary for this project. First, a new attribute was created to denote census tracts as metropolitan, micropolitan, or rural based on the county in which they were located. Next, 'Low Access' tracts were filtered and

summarized by setting (metropolitan, micropolitan and rural) to calculate the total population living in low access tracts and the percentage by setting living in low access tracts. Finally, food insecure tracts (low income and low access) were further queried from the low access tracts, tallied descriptive statistics.

Using data provided by the USDA, food security data at the census tract level was developed for only North Carolina from every census tract in the United States. A dataset composing the 2,184 census tracts in North Carolina was pared down from a dataset containing more than 72,000 records for the entire United States. Census tracts were denoted as metropolitan, micropolitan, or rural based on their MSA designation according to the county in which they were located. Calculations were used to derive some basic descriptive statistics for each setting based on attributes (Low Access and then Low Access/Low Income denoting food insecurity) provided by the data.

Within these food insecure census tracts, statistics about race, ethnicity, and age can be compared between food secure and food insecure tracts. To determine how and even if statistical differences exist between various races collected by the census (White, Black, Asian, Native Hawaiian, and Other Pacific, American Indian and Alaska Native, Multi-race), ethnicity (Hispanic, non-Hispanic), and age (under age 17, over age 65) within rural census tracts, each set of outcomes (rural food insecure vs. rural food secure) was compared using an independent t-test (or independent samples t-test). It determines if there was a statistical difference between the two cohorts in the rural region (food insecure vs. food secure). Using the sample size, the mean and standard deviation of the datasets in question, this test helps determine the criteria to reject the Null hypothesis (for example, percent of younger residents in rural food secure regions is equal to the percent of younger residents in rural food secure residents) and accept the alternate hypothesis (for example, percent of younger residents in rural food secure regions is not equal to the percent of younger residents in rural food secure regions). This was run for each of the race, ethnicity, and age variables.

Results

Utilizing data provided by the United States Department of Agriculture, census tracts denoted as metropolitan, micropolitan and rural were queried and analyzed for the state and then further queried to look

Table 1: Breakdown of Population Based on Total Population, Low Access and Food Insecure (Low Access and Low Income) based on Metropolitan, Micropolitan or a Rural Setting.*

Total	Metropolitan	Micropolitan	Rural
# Census tracts	1,578	369	237
Total Population	6,950,249	1,543,842	1,041,392
% Total Population	72.89%	16.19%	10.92%
Low Access			
# Census tracts	716	120	70
Total Population	3,381,151	497,645	361,872
% Total Population	48.65%	32.23%	34.75%
Low Income			
# Census tracts	622	197	133
Total Population	2,591,659	839,304	598,094
% Total Population	37.29%	55.01%	57.43%
Food Insecure			
# Food Insecure (Both Low Access and Low Income) Tracts	255	56	42
Total Population Living in Food Insecure Tracts	1,151,008	232,994	209,820
% Total Population Living in Food Insecurity	16.56%	15.09%	20.15%
% Low Access Population Living in Food Insecurity	34.04%	46.82%	57.98%

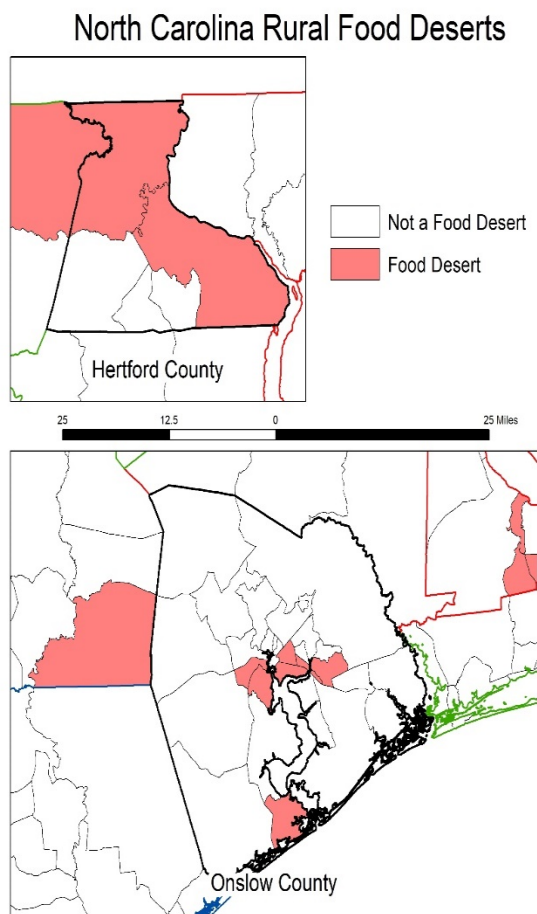
*Based on 2010 Census Data.

Table 2: Comparison of Races and Ethnicities (as a Percentage of the Total within Census Tracts) in Rural Food Secure Regions versus Rural Food Insecure Regions.

<i>Race</i>	Rural Food Insecure	Rural Food Secure
White	57.68***	74.27***
Black	33.68***	17.99***
Asian	.82	.79
Native Hawaiian / Other Pacific Islander	.14***	.07***
American Indian / Native Alaskan	.86	1.83
Multi-race	6.82**	5.04**
Ethnicity		
Hispanic	8.78**	6.06**
Age		
Young People (<17)	23.49**	21.23**
Older People (>65)	14.57**	17.34**
Statistically different with the following confidence:		
* $\rho < .1$ ** $\rho < .05$ *** $\rho < .01$		

for low access and food insecure (low access and low income) using data provided by the United States Census and United States Department of Agriculture in North Carolina. Understandably, metropolitan census tracts accounted for almost 73% of North Carolina's population, with nearly 7 million people labeled as metropolitan. Micropolitan accounted for just over 1.5 million in population followed by rural at just over 1 million in population. These are highlighted in Table 1, and a map of these are highlighted in Figure 3.

Figure 2: USDA Food Rural Deserts in Hertford and Onslow Counties



Running queries for low access, about 48.65% of metropolitan residents were classified as low access, followed by rural at 34.75% and then micropolitan at 32.23%. Finally, food insecure tracts (low income and low access) were queried from those low access census tracts. While rural areas had many fewer people living in food insecurity than its metropolitan and micropolitan counterparts (209,820 vs. 1,151,008

vs. 232,994 respectively), a higher percentage of rural residents live in food insecurity (20.15% vs. 16.56% vs. 15.09% respectively) and a higher rate of low access rural residents living in food insecurity (57.98% vs. 34.04% vs. 46.82% respectively). The last of these numbers further exacerbate the fact that rural residents suffer from the brunt of both poor access and low income as barriers to food security with higher frequency than their non-rural counterparts. Places in North Carolina Where Rural Food Security is an Issue

Of the 42 rural food insecure tracts in North Carolina, Onslow County (pictured) had the most significant number with eight food insecure tracts, followed by Bertie and Bladen with three food insecure tracts, followed by Ashe, Craven, Duplin, Hertford (pictured), Macon, Sampson and Wayne with two food insecure tracts each. In terms of percentages, Hyde County, composed of just one census tract which also happens to be food insecure, had 100% of its residents living in food insecurity, followed by Bertie (81.43%), Hertford (54.59%), and Bladen (52.28%). All of these counties are located in the eastern part of the state, with Hyde, Hertford, and Bertie Counties located in the northeast, Bladen situated in the southeastern part of the state, and Wayne located between them. A quick analysis of micropolitan counties, which have considerable areas that could be considered rural, shows counties in the southeastern and eastern part of the state such as Scotland (69.06% of residents living in food insecurity), Dare (63.30%), Carteret (60.86%), Lenoir (48.93%) and Richmond (47.54%) being the most food insecure.

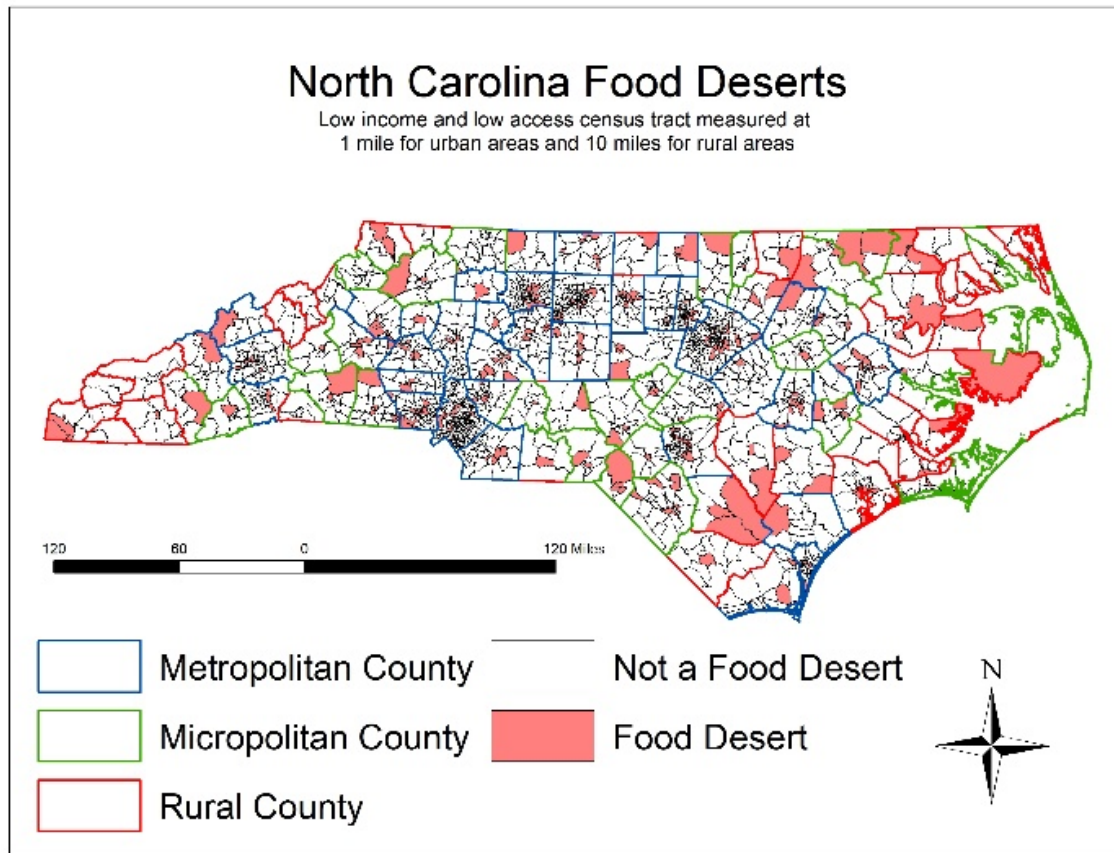
Groups Most Impacted by Rural Food Insecurity

The aforementioned results highlight rural food insecurity is a pressing problem in North Carolina and specific counties in North Carolina, most notably in the eastern and southeastern part of the state. Another goal of this research was to determine to what extent different races, ethnicities, and ages may be impacted by rural food security. This was done using the 237 rural census tracts exported to a separate file. An independent t-test was run between the food insecure (n=42) and food secure (n=195) census tracts against different demographic variables collected and calculated using the USDA data via the information provided by the United States Census. From the results in Table 2, the percentage of White residents in rural food insecure regions (57.68%) is statistically less than the percentage of White residents in rural food secure regions (74.27%) with 99% confidence. However, the percentage of Black residents is statistically higher in rural food insecure regions than

rural food secure regions with that same confidence. Furthermore, the percentage of Multi-race, Native-Hawaiian and Pacific Islander, Hispanic and younger (age 0 to 17) residents was statistically higher in food

insecure regions than food secure regions in rural areas. In addition to White residents, older residents (over the age of 65) were statistically less likely to live in food insecure regions.

Figure 3: USDA Food Access Atlas for North Carolina



Conclusion and Discussion

Conclusion

Our ability to lead a healthy lifestyle results from many tangible and intangible factors. They include genetic predisposition, exercise, smoking, alcohol consumption, work environment, lifestyle, and diet. Diet and, specifically, people's access to healthy food is just one of these many factors. The concepts of food insecurity and resulting food deserts across North Carolina transcend socio-economics, political affiliations, race, rurality/urbanity, and have sociological impacts. While various definitions and applications exist, food deserts, representing areas where people live in food insecurity, involve both a distance (to healthy food) and poverty component. With the development and democratization of digital data by organizations such as the USDA, the analysis and visualization of food insecure regions are

relatively straightforward. An example is the USDA Food Access Atlas, the gold standard for measuring food access in the United States (Economic Research Service 2019) which measures explicitly food insecure regions (low income and low access) as well as the individual components that make up this metric through the data analyzed in this project as seen in Figure 3 for North Carolina. The data composing these maps is downloadable and can be analyzed using desktop applications as this project did.

Furthermore, however, the definition is applied; the term rural implies a scarcity of resources typically available to urban/suburban residents and serves as the focus of this paper. These various resources are countless and include healthy food, broadband access, mental health services, public transportation, polling places, quality health care, good schools, extracurricular activities for children, and higher-paying jobs, to name just a few. In terms of maintaining food security, reliance on vehicles is

necessary as rural residents cannot typically walk, bike, or take public transportation to procure healthy food. Combined with a poverty component, which is more rampant in rural areas as more than half (57.43%) of the rural population is classified as low income compared to metropolitan (37.29%) and micropolitan (55.01%) areas, they make a potentially deadly combination.

An argument can be made that more people live in food insecurity in urban regions, where people should focus a majority of resources; however, rural regions had the greatest percentage of people living in food insecurity (low access and low income) at just over 20%. However, in metropolitan food insecure tracts, 10.65% of households do not have access to a vehicle, compared to 7.64% for rural food insecure tracts (significant at $p < .05$). This limits access to grocery stores using individualized vehicular transportation, but metropolitan residents have the luxury of walking, public transportation, and ride shares more than their rural counterparts. Regions in the eastern part of the state are most impacted by rural food insecurity and are most pronounced in counties like Onslow, Bertie, Bladen, and Wayne Counties. This research highlights differences in the confluence of food accessibility and income between these counties and those rural regions in the western part of the state, such as Macon, Yancey, Polk, and Avery Counties, where these differences do not exist. Furthermore, more than half (58%) of people living in low access census tracts in rural regions were food insecure. These dwarf the numbers for micropolitan (47%) and metropolitan (34%) regions and highlights the fact that those populations most economically vulnerable to food insecurity in rural regions (i.e., low income) are located further from healthy food than their metropolitan and micropolitan counterparts.

An independent t-test compared the means for various attributes for 42 rural food insecure tracts against the same characteristics for 195 rural food secure tracts. Using the race designations provided by the United States Census, significant differences were found between White residents (statistically higher percentage of White residents in rural food secure regions compared to rural food insecure regions). Races with statistically higher percentages living in food insecure regions included Black, Native Hawaiian / Other Pacific Islander, and those classified as Multi-race. In addition, rural Hispanic residents were statistically more likely to live in food insecure regions than food secure regions in terms of ethnicity. In terms of age, the young (under the age of 17) were also statistically more likely to live in rural food insecurity. These results reinforce work by Holston et al. (2020) and Sanson and Hannibal (2021), which

highlight racial minorities have poorer access to healthy food, even in rural regions.

While improving rural food security involves a myriad of issues (better distribution models, changing household buying patterns, education, policy, etc.), these results highlight many of North Carolina's most vulnerable populations (racial and ethnic minorities, the young) suffer from the brunt of both low income and poor access to healthy food at higher rates than their majority and older counterparts. A place to begin is the Coastal Plain region of the state, where 37 of 161 (22.98%) rural census tracts were denoted as food insecure, compared to just 6.58% (5 of 76) of rural census tracts for the rest of the state. While this paper addresses physical access to food, income, and the racial and ethnic makeup of those who are most food-compromised, connections to unhealthy eating through spending patterns, long-term health outcomes through the North Carolina vital statistics database and qualitative analysis can further model food insecurity at a scale that can have meaningful and measurable impact.

Discussion

While this analysis was comprehensive, it must be noted how distance can be relative in various ways. The USDA utilizes distances to measure food insecurity at 1 mile in urban regions and 10 miles in rural regions. However, the USDA does provide different flags for other distances (.5 miles in urban regions and up to 20 miles in rural regions). Utilizing these different values may yield nuanced results which may not entirely align with the results garnered from this research. Furthermore, the USDA measures the distance between a supermarket and a census tract using Euclidean (straight-line) distance since it is reasonably easy to calculate. However, this is not practical as people sometimes travel on roads that take circuitous routes, especially in rural regions. Given the low density of roads in rural regions, a 10 miles away (Euclidean distance) supermarket may be 20 miles away by car. In urban regions with more roads, the difference between driving distance and Euclidean distance is not as stark. A Geographic Information System (GIS), which can make real-world measurements using digital data, can calculate these driving distances, which can be brought into the analysis.

Distance is a valuable way to measure food security, although it may not be as practical as driving time. Using a simple application on our phone, it is fairly easy to calculate the driving time between two locations. When given a choice, one will bypass the shortest route (in terms of distance) for the fastest route (in terms of time). With better technologies,

research (Burns and Inglis 2007, Ver Ploeg et al. 2009, Jiao et al. 2009) has utilized travel time as another indicator for food access, just like Euclidean and driving distance.

Lastly, the definition and application of rural vary. The original data provided by the USDA contains a flag for urban; however, it has its limitations as census tracts that are not urban should not be considered rural. However, a quick analysis of these data found that 61.53% of low-access residents living in non-urban census tracts were food insecure, mimicking the results from Table 1. As a result of this overgeneralization, this research utilized a three-tier classification based on the MSA county within which the census tract was located. This county-level measurement devised by the OMB defines rural counties to be neither metropolitan (have at least one urban area > 50,000 population) nor micropolitan (have at least one urban area between 10,000 and 50,000 population).

Other classifications of rural exist. The United States Census defines rural as all territory, population, and housing units not located within urbanized areas (UAs) and urban clusters (UCs). An urbanized area consists of densely developed territory that contains 50,000 or more people. An urban cluster consists of densely developed territory with at least 2,500 but fewer than 50,000 people (Ratcliffe et al. 2016). The United States Department of Agriculture provides a Rural-Urban Commuting Areas (RUCA) classification through the Economic Research Service website (Economic Research Service 2020) at the ZIP code scale. RUCA stores ordinal codes (1 through 10) to delineate metropolitan, micropolitan, small town, and rural commuting areas based on the size and direction of the primary (largest) commuting flows. Employing different definitions of rural using these same data may also change research results, and exploring this disparity may be the subject for future research.

References

- Austin, Bryn., Melly, Steven., and Brisa Sanchez. 2005. "Clustering of Fast-Food Restaurants Around Schools: A Novel Application of Spatial Statistics to the Study of Food Environments." *American Journal of Public Health* 95: 1575–1581.
- Bell, Judith, and Standish, Marion, 2009. "Building healthy communities through equitable food access." *Community Development Investment Review* 5(3):75-87.
- Block, Jason, Scribner, Richard and Karen DeSalvo. 2004. "Fast Food, Race/Ethnicity, and Income: A Geographic Analysis." *American Journal of Preventative Medicine* 27: 211–217.
- Brindle-Fitzpatrick, Susan. 2015. "Food deserts or food swamps?: A mixed-methods study of local food environments in a Mexican city." *Social Science and Medicine* 142: 202-213.
- Burns, Cate. and Adam Inglis. 2007. "Measuring Food Access in Melbourne: Access to Healthy and Fast Foods by Car, Bus and Foot in an Urban Municipality in Melbourne." *Health and Place* 13: 877–885.
- Chen, Xiang, and Jill Clark. 2013. "Interactive Three-Dimensional Geovisualization of Space–Time Access to Food." *Applied Geography* 43: 81–86.
- Centers for Disease Control and Prevention. 2009. "The State Indicator Report on Fruits and Vegetables." Washington, DC: U.S. Department of Health and Human Services. Retrieved June 24, 2021 (<http://www.fruitsandveggiesmater.gov/indicator-report>).
- Chrisinger, Benjamin. 2016. "A Mixed-Method Assessment of a New Supermarket in a Food Desert: Contributions to Everyday Life and Health." *Journal of Urban Health* 93(3): 425-437.
- Clarke, Graham., Eyre, Heather. and Cliff Guy. 2002. "Deriving Indicators of Access to Food Retail Provision in British cities: Studies of Cardiff, Leeds and Bradford." *Urban Studies* 39(11): 2041-2060.
- Coleman-Jensen Alisha, Rabbitt, Matthew, Christian, Gregory and Anita Singh. 2019. Household Food Security in the United States in 2018. United States Department of Agriculture Economic Research Service.
- Economic Research Service (ERS), U.S. Department of Agriculture (USDA). 2019a. "Food Access Research Atlas." Washington, DC: Economic research service. Retrieved July 14, 2021 (<https://www.ers.usda.gov/data-products/food-access-research-atlas/>).
- Economic Research Service (ERS), U.S. Department of Agriculture (USDA). 2019b. "Food Access Research Atlas – Download the Data." Washington, DC: Economic research service. Retrieved October 17, 2021 (<https://www.ers.usda.gov/data-products/food-access-research-atlas/download-the-data/>).
- Economic Research Service (ERS), U.S. Department of Agriculture (USDA). 2020. "Rural-Urban Commuting Area Codes." Washington, DC: Economic research service. Retrieved July 14, 2021 (<https://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes.aspx>).

- Feeding America. 2020. "Mapping the meal gap." Chicago, IL: Feeding America. Retrieved July 1, 2021 (<https://map.feedingamerica.org/>).
- Furey, Sinéad., Strugnell, Christopher. and Heather McIlveen. 2001. "An Investigation of the Potential Existence of 'Food Deserts' in Rural and Urban Areas of Northern Ireland." *Agriculture and Human Values* 18: 447–457.
- Hallett, Lucius. And David McDermott. 2011. "Quantifying the extent and cost of food deserts in Lawrence, Kansas, USA." *Applied Geography* 31: 1210–1215.
- Holston, Denise, Stroope, Jessica, Greene, Matthew., and Bailey Houghtaling. 2020. "Perceptions of the Food Environment and Access among Predominantly Black Low-Income Residents of Rural Louisiana Communities." *International Journal of Environmental Research and Public Health* 17. doi: [10.3390/ijerph17155340](https://doi.org/10.3390/ijerph17155340).
- Hossfeld, Lesile. and GinaRico. 2018. "Looking for food: Food access, food insecurity, and the food environment in rural Mississippi." *Family Community Health* 41. doi: [10.1097/FCH.0000000000000182](https://doi.org/10.1097/FCH.0000000000000182).
- Huble, Teresa. 2011. "Assessing the Proximity of Healthy Food Options and Food Deserts in a Rural Area in Maine." *Applied Geography* 31(4): 1224–1231.
- Jiao, Junfendg, Moudon, Anne., Ulmer, Jared, Hurvitz, hillip. and Adam Drewnowski. 2012. "How to Identify Food Deserts: Measuring Physical and Economic Access to Supermarkets in King County, Washington." *American Journal of Public Health* 102(10): 32–39.
- Killian, Pat. 2019. "In One of NC's Many Food Deserts, A Co-Op Grocery Store Closes." *The Progressive Pulse*. Retrieved June 14, 2021 (<http://pulse.ncpolicywatch.org/2019/01/14/in-one-of-ncs-many-food-deserts-a-co-op-grocery-store-closes/#sthash.AgdLYmY4.0o5Ze4Cv.dpbs>).
- Leddy Anna, Whittle, Henry., Shieh, Jacqueline, Ramirez, Catalina, Ofotokun, Ighovwerha, SheriaWeiser. 2020. "Exploring the role of social capital in managing food insecurity among older women in the United States." *Social Science and Medicine* 265. <https://doi.org.proxy006.nclive.org/10.1016/j.socscimed.2020.113492>
- Lewis, LaVonna., Sloane, David, Nascimento, Lori, Diamant, Allison. Guinyard, Joyce., Yancey, Antronette. and Gwendolyn Flynn. 2005. "African Americans' Access to Healthy Food Options in South Los Angeles Restaurants." *American Journal of Public Health* 95(4): 668-73.
- Mamen, Katy. 2007. "Facing Goliath: Challenging the Impacts of Supermarket Consolidation on our Local Economies, Communities, and Food Security - Policy Brief." *The Oakland Institute* 1(3): 1-8.
- McEntee, Jesse, and Julian Agyeman. 2010. "Towards the Development of a GIS Method for Identifying Rural Food Deserts: Geographic Access in Vermont, USA." *Applied Geography* 30(1): 165–176.
- Miller, Michael, Middendorf, Gerald and Spencer Wood. 2015. "Food Availability in the Heartland: Exploring the Effects of Neighborhood Racial and Income Composition." *Rural Sociology* 80(3). <https://doi.org/10.1111/ruso.12063>
- Moore, Latetia, Diez Roux, Ana, Nettleton, Jennifer and David Jacobs. 2008. "Associations of the Local Food Environment with Diet Quality – A Comparison of Assessments Based on Surveys and Geographic Information Systems: The Multi-Ethnic Study of Atherosclerosis." *American Journal of Epidemiology* 167: 917–924.
- Morland, Kimberly., and Kelly Evenson. 2009. "Obesity Prevalence and the Local Food Environment." *Health and Place* 15(2): 491–495.
- Morton, Lois, Bitto, Ella, and Mary Jane Oakland. 2005. "Solving the Problems of Iowa Food Deserts: Food Insecurity and Civic Structure." *Rural Sociology* 70(1): 94–112.
- Morton, Lois, and Troy Blanchard. 2007. "Starved for Access: Life in Rural America's Food Deserts." *Rural Realities* 1(4): 1–10.
- Mulrooney, Timothy, McGinn, Christopher. Branch, Benjamin, Madumere, Chibuike. and Byron Ifediora. 2017. "A New Raster-Based Metric to Measure Relative Food Availability in Rural Areas: A Case Study in Southeastern North Carolina." *Southeastern Geographer* 57(2): 151 - 178.
- Parsons, Sarah. 2012. "An Evaluation of the Food Desert Definition in Durham, North Carolina." Master's Thesis, Nicholas School of the Environment, Duke University.
- Paul, Christopher, Paul, John and Rosa Anderson. 2019. "The Local Food Environment and Food Security: The Health Behavior Role of Social Capital." *International Journal of Environmental Research and Public Health* 16(24): 5045. <https://doi.org/10.3390/ijerph16245045>.
- Powell, Lisa, Slater, Sandy, Mirtcheva, Donka, Bao, Yanjun and Frank Chaloupka. 2007. "Food Store Availability and Neighborhood Characteristics in The United States." *Preventive Medicine* 44: 198-95. doi: [10.1016/j.ypmed.2006.08.008](https://doi.org/10.1016/j.ypmed.2006.08.008)
- Ratcliffe, Michael, Burd, Charlynn, Holder, Kelly and Alison Fields. 2016. "Defining Rural at the U.S.

- Census Bureau.” Washington, DC: American Community Survey and Geography Brief. Retrieved June 21, 2021. (https://www2.census.gov/geo/pdfs/reference/ua/Defining_Rural.pdf).
- Rodriguez, Luisa. 2008. “The Quest for Answers: Food and Energy Security.” *Trade Negotiations Insight* 7(6).
- Rummo, Pasquale, Albrecht, Sandra, and Penny Gordon-Larsen. (2015). “Field validation of food outlet databases: the Latino food environment in North Carolina, USA.” *Public Health Nutrition* 18(6): 977 – 982.
- Sansom, Garrett. and Bryce Hannibal. 2021. “Disparate access to nutritional food; place, race and equity in the United States.” *BMC Nutrition* 7: 29. <https://doi.org/10.1186/s40795-021-00434-2>.
- Shannon, Jerry. 2015. “Rethinking Food Deserts Using Mixed-Methods GIS.” *Cityscape* 17(1): 85-96.
- Towns, Tangela and Richard Moyer. 2020. “Accessible Rations: Food Environment and Race – The Case of Forsyth County, North Carolina.” *Sociation* 19(1): 1 – 14.
- United States Census. 2019. “Metropolitan and Micropolitan Statistical Areas Population Totals and Components of Change: 2010-2019.” Washington, DC: United States Census Bureau. Retrieved June 6, 2021 (<https://www.census.gov/data/datasets/time-series/demo/popest/2010s-total-metro-and-micro-statistical-areas.html>).
- Van Hoesen, John, Bunkley, Brandy. and Cody Currier. 2013. “A GIS-Based Methodology toward Refining the Concept of Rural Food Deserts: A Case Study from Rutland County, Vermont.” *Journal of Agriculture, Food Systems, and Community Development* 3(2): 61–76.
- Ver Ploeg, Michelle, Breneman, Vince, Farrigan, Tracey, Hamrick, Karen, Hopkins, David, et al. 2009. “Access to affordable and nutritious food—measuring and understanding food deserts and their consequences: Report to congress.” Washington, D.C.: United States Department of Agriculture, Economic Research Service.
- Walker, Renee, Keane, Christopher, and Jessica Burke. 2010. “Disparities and Access to Healthy Food in the United States. A Review of Food Deserts Literature.” *Health and Place* 17: 876-884.
- Whitley, Sarah. 2013. “Changing Times in Rural America: Food Assistance and Food Insecurity in Food Deserts.” *Journal of Family Social Work* 16: 36 - 52.
- Zenk, Shannon, Schulz, Amy, Israel, Barbara, James, Sherman, Bao, Shuming and Mark Wilson. 2005. “Neighborhood Racial Composition, Neighborhood Poverty, and the Spatial Accessibility of Supermarkets in Metropolitan Detroit.” *American Journal of Public Health* 95(4): 660-667.
- Zenk Shannon. and Lisa Powell. 2008. “US secondary schools and food outlets.” *Health and Place* 14: 336–346.

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