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A Comparative Assessment of Food Deserts Using Geographic Information Systems (GIS) in El Paso County, TX and Loudoun County, VA

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A COMPARATIVE ASSESSMENT OF FOOD DESERTS USING GEOGRAPHIC
INFORMATION SYSTEMS (GIS) IN EL PASO COUNTY, TX, AND
LOUDOUN COUNTY, VA

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by

Amit Ugamraj Raysoni

2018

DEDICATION

I dedicate this thesis to my parents and sister for their steadfastly support without which this journey would not have been possible.

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INFORMATION SYSTEMS (GIS) IN EL PASO COUNTY, TX, AND
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by

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THESIS

Presented to the Faculty of the Graduate School of

The University of Texas at El Paso

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Department of Public Health Sciences

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ABSTRACT

BACKGROUND & SIGNIFICANCE: Consumption of processed foods high in sodium and fat can have a plethora of health complications, including, but not limited to hypertension, high cholesterol levels, obesity, diabetes and cancer. Previous studies have documented that lack of access to viable healthy eating options— grocery stores selling affordable fresh fruits and vegetables – in any neighborhood or area can result in negative public health outcomes. These areas devoid of such grocery stores and healthy eating options can be classified as ‘Food Deserts’, as per one of the criteria adopted by the United States Department of Agriculture (USDA). In addition, if a census tract that has more than 20 percent poverty rate and the median family income is less than or equal to 80 percent of the state-wide median family income can also be classified as a ‘Food Desert’. **HYPOTHESES:** This research work is premised on two hypotheses: 1) census tracts that are predominantly of Hispanic/Latino origin would have a dearth of grocery stores in contrast to more affluent and mixed neighborhoods, and 2) lack of access to public transportation can hamper people’s access to grocery stores subsequently impacting their overall health status in both the counties. **AIMS & OBJECTIVES:** Using various advanced Geographic Information Systems (GIS) techniques, this research work identified and compared the census tracts in El Paso County, TX and Loudoun County, VA that could be classified as a typical ‘Food Desert’. Loudoun County is the richest county in the United States in terms of median income per household (\$ 118,000) and is an apt contrast with the El Paso County, TX that is not only majority-minority (81.3% Hispanic/Latino) but also has a low median income per household (\$ 41,637). **METHODS:** Census tracts for both counties were obtained from US Census 2017 TIGER/Line Shapefiles. Various demographic and Socio-Economic variables were obtained from the US Census Bureau’s American Community Survey,

2015 ACS 5-year estimates. GIS spatial techniques such as Clusters Mapping, Cluster and Outlier Analysis, and Hot Spot Analysis were employed to test the two hypotheses. **RESULTS:** Certain census tracts in the southeast, eastern, and north-west part of El Paso County could be categorized as 'Food Deserts'. Similarly, census tracts in the north-central, north-western and south-western part of Loudoun County could also be deemed as 'Food Deserts'. Transportation was not an issue in terms of access to grocery stores for the Hispanics in Loudoun County but transportation was limited in some areas in El Paso County. **CONCLUSIONS & RECOMMENDATIONS:** Findings from this research helped identify the census tracts of 'Food Deserts' in two counties populated by Hispanics, one affluent and one low-income. Information emanating from this research will help policy makers and city planners draft healthy living guidelines in terms of siting and facilitating access to grocery stores in many low-income neighborhoods.

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CHAPTER 1: INTRODUCTION

This research project focuses on the important topic of ‘Food Desert.’ Typically, the word desert connotes an arid environment that is devoid of any greenery or water and generally a place that can hardly sustain thriving population. In sharp contrast, an oasis is a place that typically symbolizes life and sustenance. It is well known that life is not possible without food and nourishment. Although, a person can survive without food for a few days, there comes a time when the human body can no longer endure the pangs of hunger and ultimately results in the demise of the person. The term ‘Food Desert’ came into prominence in the social sciences lexicon about three decades ago. It was first used in Western Scotland by a local government official in charge of a public housing sector scheme (Cummins and Macintyre, 2002).

Our fast-paced and sedentary lifestyles in the 21st century have seen an upsurge in food habits that are not only unwise but also detrimental to our overall health. Whereas a few decades ago having a wholesome meal at the dinner table was a daily family affair, we find ourselves in an era where the mantra is ‘Grab and Go’, ‘TV Dinners’, and one dollar meals. It is, indeed, tragic and sad that instead of consuming fresh fruits and vegetables, processed food items rule the roost in this day and age.

A nationwide initiative on healthy eating options was instituted by First Lady, Mrs. Michelle Obama in the late 2000s. This harmless initiative, however, was received by some as intrusion into personal choices. But we again live in much divided and polarized world where her harmless initiatives were construed by some as intrusion into personal choices. Misconstruing things and taking things off the tangent for political gains are harmful in the long run.

Consumption of processed foods high in sodium and fat can have a plethora of health complications (Deaton and Lubotsky, 2003). Hundreds of studies have documented that lack of access to viable eating options can result in chronic health conditions such as hypertension, high cholesterol levels, obesity, diabetes, and cancer (Walker et al., 2010). The American landscape, unfortunately, today is rife with areas that can be typically classified as a ‘Food Desert’. It becomes important here to first define the concept of what a ‘Food Desert’ actually is?

The term ‘Food Desert’ came into prominence in the mid-1990s in the United Kingdom. The UK Nutrition Task Force’s Low Income Project Team defined ‘Food Deserts’ as ‘*areas of relative exclusion where people experience physical and economic barriers to accessing healthy food*’ (McKinnon et al., 2009; Reisig and Hobbins, 2000).

The United States Department of Agriculture (USDA) adopts various criteria to define a Food Desert (Hubley 2011; USDA, 2009). An area, for example a census tract that is devoid of any fresh fruits and vegetable grocery stores can be classified as a Food Desert. In addition, a census tract that has more than 20 percent poverty rate and the median family income is less than or equal to 80 percent of the State-wide median family income is also classified as a Food Desert. Usually, a Food Desert area is located equal to greater than one mile from a census tract population centroid. Lack of access to fresh fruits and vegetables in a person’s diet can have wide-ranging health implications.

Typically, a Food Desert is an occurrence in communities or neighborhoods that are predominantly underserved and the ethnic composition of such communities is typically a minority group. In addition, such areas have higher concentrations of liquor and tobacco stores, pay day loans outlets, fast food centers (Hallett and McDermott, 2011). As per the USDA, there are approximately 19 million people in this country who live in low-income census tracts and are

more than a mile from a nearest grocery store or super-market (USDA, 2017). Another definition of food desert as suggested by Beaulac et al., 2009 is that food deserts in an urban landscape are areas where fast food restaurants are ubiquitous.

For the purposes of this research work, it is necessary to appropriately define the term ‘Grocery Store’. As per the North America Industry Classification System (NAICS) definition a conventional food store is an establishment such as a supermarket (Walmart, Food King, Sprouts), specialty food markets (such as meat markets, fish or seafood market, fruit and vegetable market), and ethnic grocery stores (such as a Bodega, a Middle Eastern Grocery Store, or an Indian or Pakistani South Asian Grocery Store) (Mckinnon et al., 2009, Sharkey, 2009; US Census, 2017). For this research, all the above three- i.e. supermarkets, specialty food markets and ethnic grocery stores are considered as ‘grocery stores’.

CHAPTER 2: BACKGROUND AND SIGNIFICANCE

The area of study for this thesis research work involves two counties in the United States of America: the County of El Paso in the State of Texas and Loudon County in the Virginia Commonwealth. Loudon County is the richest county in the United States and, precisely, that was the reason why it was chosen to help assess the comparison in the prevalence of food deserts in both the counties.



Figure 1: Location of El Paso County in the State of Texas (Source: Wikipedia)

El Paso County in far-west Texas grapples with high obesity and diabetes rates. Figure 1 shows the location of El Paso County in the state of Texas. Many census tracts in this county could be classified as Food Deserts. Below are some important features of this county as per the latest US Census Bureau estimates:

- Population Estimates: 837, 918.
- Hispanic/Latino Population: 81.3 %.
- Poverty Estimates: 20.3%.

- Median Household Income: \$ 41,637.
- Per capita income the past 12 months: \$ 18,880.

Spanish is the primary language for majority of the people in this region (US Census Bureau, 2017). Based on these socio-demographic and economic features, it stands to reason to identify those areas of this county that may be classified as a typical 'Food Desert'.

The following health indicators (Table 1) pertaining to food deserts and obesity prevention in the El Paso County are obtained from this website and are tabulated as follows:

Table 1: El Paso County Benchmarks and Health Indicators

Benchmarks/Health Indicators	Value
1. Access to Exercise opportunities	81.0 %
2. Recreation & Fitness Facilities	0.08 facilities per 1000 population
3. Farmers Market Density	0.02 markets per 1000 population
4. Fast Food Restaurant Density	0.68 restaurants per 1000 population
5. Grocery Store Density	0.14 stores per 1000 population
6. Children with low access to a grocery store	5.4%
7. People 65 and above with low access to a grocery store	1.6%
8. Low Income and low access to a grocery store	9.6%
9. Households with no car & low access to a grocery store	1.2%
10. Food Environment Index ^a	8.4
11. Child Food Insecurity Rate ^b	23.7%
12. Food Insecurity Rate ^c	8.1%
13. Adults who are obese	28.5%
14. Adults who are overweight or obese	67%

Source: <http://www.healthypasodelnorte.org/indicators/index/dashboard?alias=Obesity>, Accessed on April 30, 2018.

^a The **Food Environment Index** combines two measures of food access: the percentage of the population that is low-income and has low access to a grocery store, and the percentage of the population that did not have access to a reliable source of food during the past year (food insecurity). The index ranges from 0 (worst) to 10 (best) and equally weights the two measures.

^b The **Child Food Insecurity Rate** shows the percentage of children (under 18 years of age) living in households that experienced food insecurity at some point during the year.

^c The **Food Insecurity Rate** indicator shows the percentage of the population that experienced food insecurity at some point during the year.

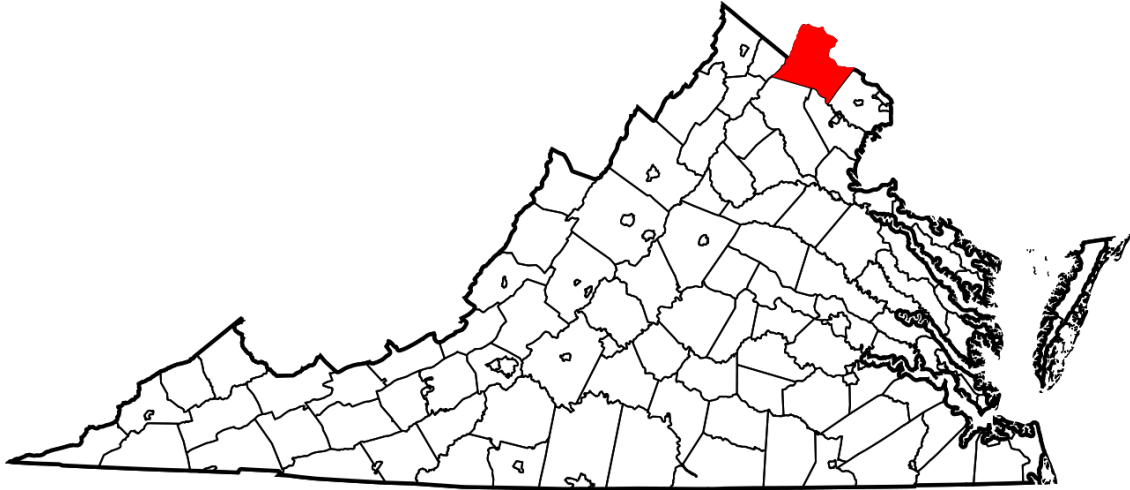


Figure 2: Location of Loudoun County in the Commonwealth of Virginia (Source: Wikipedia)

Figure 2 above shows the location of Loudoun County in the Commonwealth of Virginia. Below are some estimates for Loudoun County (US Census Bureau, 2017, Loudoun County, 2017):

- Population Estimates: 392,711
- Hispanic/Latino Population: 13.7 %.
- Poverty Estimates: 2.6%
- Median Household Income: \$ 134,464.
- Per capita income the past 12 months: \$ 47,495.

Based on the above information, it was decided to do a comparative assessment about food deserts between these two counties. Given the fact that Loudoun County is the richest county in the United States, this research work would help focus on the ground realities about food deserts between this county and the El Paso County which has a far less median income.

CHAPTER 3: LITERATURE REVIEW

A growing body of literature has documented that childhood obesity is a major cause of concern in the United States (Dalenius et al., 2012, Grills et al., 2014). Childhood obesity can lead to a suite of health complications such as high blood pressure, cardiovascular issues, diabetes, asthma, depression, peer pressure, and other behavioral problems (Keener et al., 2009; Pulgaron 2013; Daniels et al. 2006). Approximately 39% of African-American and Latino children from the ages of two to nine are overweight or obese in the United States (Dalenius et al., 2012). Lower socio-economic conditions is also one of the factor that can contribute to high levels of obesity (Keener et al., 2009).

Access to stores selling fresh fruits and vegetables can have a beneficial health impact on the community. This is true especially for communities of color and communities with low socio economic status. A study conducted by Cheadle et al. (1991) is a testimony to this fact. This study assessed individual dietary practices in 12 communities via telephone survey. The researchers documented positive and statistically significant correlations between positive health outcomes and availability of fresh fruits and vegetables at grocery stores at the community and zip code level.

Another study conducted at Wake County, NC examined the accessibility of grocery stores (measured in terms of distance) and the overall diet quality in 918 pregnant women (Laraia et al., 2004). The findings from that particular study suggest that the diet of pregnant women living within two miles of a grocery store was better than those women who lives greater than four miles.

Morland and colleagues conducted a food environment and residence diet study in 208 census tracts in the states of Maryland, North Carolina, Mississippi, and Minnesota involving 10,

623 atherosclerotic patients (Morland et al., 2002). Their findings showed that the intake of fresh fruits and vegetables for African-Americans increased by 32% for each additional supermarket in the census tract. This was in contrast to an increment of only 11 % for White Americans for the presence of one or more supermarket in their respective census-tracts.

A study on the associations between access to food stores and adolescent body mass index documented that increased availability of chain supermarkets in a community was statistically significantly associated with lower BMI compared to higher BMI in communities where the availability of convenience stores selling high obesogenic foods was greater (Powell et al., 2007a). Another study by the same research group (Powell et al., 2007b) suggested that the availability of grocery stores outlets was dependent on various socio-economic characteristics such as race, ethnicity, and income levels. The findings from this study suggest that middle-income neighborhoods have 25% more grocery stores than low-income neighborhoods. In addition, their research also showed that White neighborhoods have 48% more grocery stores selling fresh fruits and vegetables than African American neighborhoods.

A study conducted in Harlem and Brooklyn areas of New York City showed that East and Central Harlem and North and Central Brooklyn areas had high density of areas that could be classified as food desert compared to the predominantly white, and richer Upper East Side of NYC (Gordon et al., 2011). It is prudent to mention here that Harlem and Brooklyn areas of NYC have high density of African-American and other low-income population groups.

Zenk and colleagues conducted a study in metropolitan Detroit to evaluate the ‘spatial accessibility’ of supermarkets in various neighborhoods in the context of race and income levels (Zenk et al., 2005). The researchers found that in the most impoverished African-American

neighborhoods the grocery stores were on average 1.1 miles further than in White neighborhoods.

Ghost-Dastidar et al., (2014) examined the relationship between store distance, food prices, and obesity primarily in two very low-income African-American neighborhoods in Pittsburgh that were devoid of a supermarket but had 16 food stores where the participants did their food shopping. The sample size involved 1,372 households. The researchers showed statistically significant and positive associations between distance to the food stores and prices with obesity.

Dubowitz et al., (2012) studied the cross-sectional associations between food outlet locations and BMI and blood pressure for 60,755 postmenopausal women from the Women's Health Initiative Clinical Trial. Results indicated a statistically significant and negative associations between grocery store availability in a women's neighborhood (1.5 miles from her residence) and BMI. In addition, a positive association between the availability of fast food restaurants and BMI was reported. The study concluded that access and availability to grocery stores was inversely associated with hypertension.

A study investigating healthy food options was conducted in two cities in Alabama that had a contrasting socio-economic and socio-ethnic demographics (Bovell-Benjamin et al., 2009). Researchers showed that the city of Tuskagee in Macon County had high concentration of convenience stores that sold high sugar and energy dense foods such as chips, sodas etc. compared to supermarkets that had greater varieties of fresh fruits and vegetables. The city of Auburn in adjoining Lee County had better healthy eating options and had high number of national supermarkets. Tuskagee (average family income: \$34, 065) is predominantly Africa-

American compared to Auburn (average family income: \$ 65,582) which is more than 75% Caucasian.

CHAPTER 4: GOALS AND OBJECTIVES

The main objective of this research project work was to identify the census tracts in the El Paso County and Loudoun County that could be classified as a Food Desert. To that effect, two major hypotheses were postulated which are as follows:

- Census tracts that are predominantly of Hispanic origin would have a dearth of grocery stores compared to more affluent and mixed (ethnicity-wise) neighborhoods of El Paso County and Loudoun County.
- Lack of access to public transportation can hamper people's access to grocery stores subsequently impacting their overall health status in both the counties.

CHAPTER 5: METHODS

Various sources and data bases were accessed to obtain the data for this research work. Firstly, the El Paso County and Loudoun County Census Tracts were obtained from the US Census 2016 TIGER/Line Shapefiles. It is prudent to mention here that Census Tracts were chosen compared to Area by Zip codes as Census Tracts present a fine and more detailed representation of the population in any geographic unit. Demographic & Socio-Economic variables for the research work were obtained from the US Census Bureau's American Community Survey, 2015 ACS 5-year estimates.

The variables that were looked into for the El Paso County and Loudoun County were as follows:

- Percentage of Hispanics,
- Median Income,
- Percent Poverty Rate,
- Percentage of Hispanics with High School Education and Higher,
- Percentage of Non-Hispanics,
- Percentage of Limited English Speaking Households,
- Percentage of Hispanics with Transportation, and
- Percentage of Whites with High School Education and Higher.

Population-Weighted Centroids for the Census Tracts were obtained from the US Census Bureau. The Population-Weighted Centroids are an approximation of the concentration of the population for the census tract in question. The location of grocery stores was obtained from a commercial vendor titled Reference USA. The location of bus-stops and arterial road shapefiles

were obtained from the website of Paso del Norte Mapa and the Loudoun County official government website.

Various GIS tools and techniques were employed to test the hypotheses, which are described in the following paragraphs in greater detail. The most important GIS feature used was the ‘Clip’ feature. The Texas Tiger Shapefile & Virginia Commonwealth Tiger Shapefile were downloaded from the US Census Bureau website. The state code for TX is 48 and the FIPS code for the El Paso County is 141. The state code for VA is 51 and the FIPS code for the Loudoun County is 107. FIPS stands for Federal Information Processing Standards. The El Paso County geographic area was clipped from the State of Texas and saved as another layer in the Table of Contents of Arc Map. Similarly, the Loudoun County geographic area was clipped from the Virginia Commonwealth and saved as another layer in the Table of Contents Arc Map.

It is important to mention here that before the GIS analysis was initiated, a Geodatabase was formed to save all the data and the output files and the current workspace for the project was set or linked to this Geodatabase. This task was necessary and of paramount importance to avoid the inadvertent saving of GIS result outputs in other files or folders on the computer.

The next task was to convert all the Excel files from American Community Survey into a format that was easily recognizable by ArcGIS. These Excel files basically pertain to the various socio and economic-variables described previously. The Conversion Tool – Excel to Table were used from Arc Tool Box to transport this data into ArcGIS. All the Excel files after initial processing and cleaning were saved as Excel 97-2003 files to make it compatible with ArcGIS. In addition, ‘Joins and Relates’ procedure was employed to join the ACS data with the El Paso County and Loudoun County Shapefiles.

Various maps were plotted that showcased the various socio-economic and demographic variables in the El Paso County and Loudoun County. Scatter plot matrices were also plotted between race, percent poverty and median income in both the counties. Also, many tools were used from the Arc Tool Box. Spatial Statistics Tool – Mapping Clusters were used to do the Cluster and Outlier Analysis (Anselin Local Morans I) for identifying Hispanic/Non-Hispanic Hotspots in El Paso County and Loudoun County. In addition, Hot Spot Analysis (Getis-Ord Gi) were conducted to identify Hispanic/Non-Hispanic population concentrations in both the counties.

Geo-processing operations such as Buffer and Dissolve were done for the Buffer Analysis for population centroids, bus-stop locations and arterial roads to identify the census tracts that could be classified as Food Desert. In addition, Geographically Weighted Regression was done via Arc Tool Box - Spatial Statistics Tool – Modeling Spatial Relationships – Geographic Weighted Regression (GWR). The GWR regression analysis was done to model the percentage of Hispanics with various socio-economic and demographic attributes in both the counties.

CHAPTER 6: RESULTS AND DISCUSSION

This chapters comprises of various sub-sections focusing on the analyses that were accomplished in this thesis work. These are presented as follows:

6.1 DEMOGRAPHIC AND SOCIO-ECONOMIC RESULTS

Various maps were plotted to accentuate the subtle differences in Hispanic/Non-Hispanic population concentrations and various social and economic metrics in the El Paso County and Loudoun County. These metrics are:

- Median Income,
- Poverty Rate,
- Percentage of Hispanics with High School Education & Higher,
- Household Language Preference,
- Access to Own Transportation.

Figures 3-18 are the ArcGis outputs enunciating the differences between Hispanics and Non-Hispanics for the socio-economic and demographic attributes in El Paso County and Loudoun County. Some census tracts in El Paso County for which no data was available from the ACS appear as white in the outputs. These figures were perused and expounded upon for requisite interpretation. As is obvious from the demographic composition of El Paso County, and as explained before, close to 81% of the population is of Hispanic/Latino origin. There are many census tracts which are overwhelmingly of this demographic group especially in the Lower Valley region of El Paso. The median income in every census tract is a more accurate representation of the amount of poverty that is pervasive in this county. Food desert locations typically are also a reflection of high poverty levels. Again certain areas of the Lower Valley and Central part of the El Paso County experience high poverty rates (almost to the extent of 69%).

Percentage of Hispanics in El Paso County

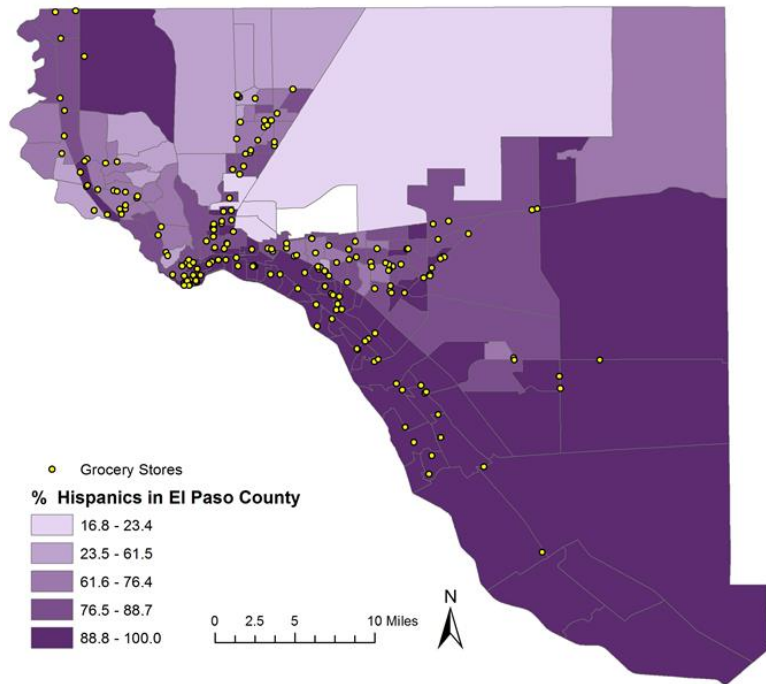


Figure 3: Percentage of Hispanics in El Paso County

Percentage of Hispanics in Loudoun County

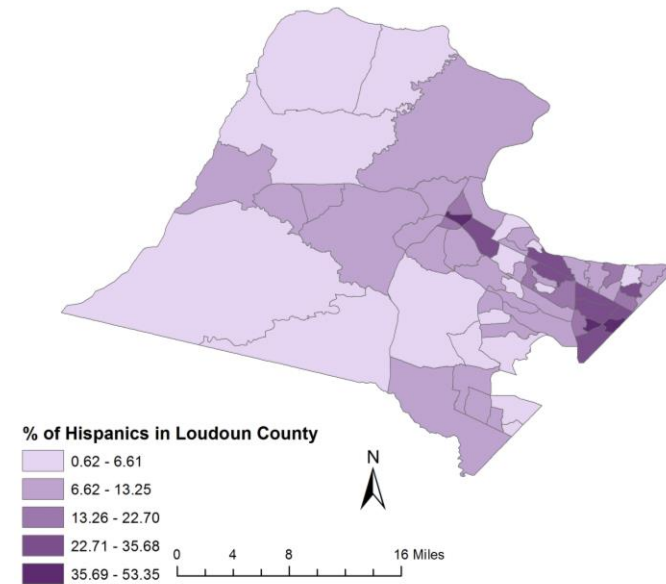


Figure 4: Percentage of Hispanics in Loudoun County

Median Income (US Dollars) in El Paso County

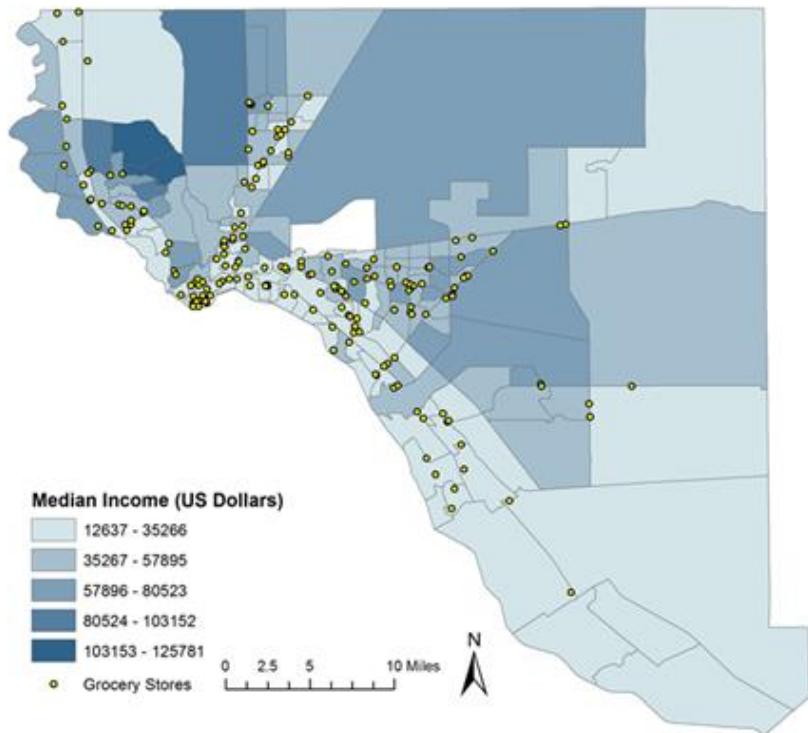


Figure 5: Median Income (US Dollars) in El Paso County

Median Income (US Dollars) in Loudoun County

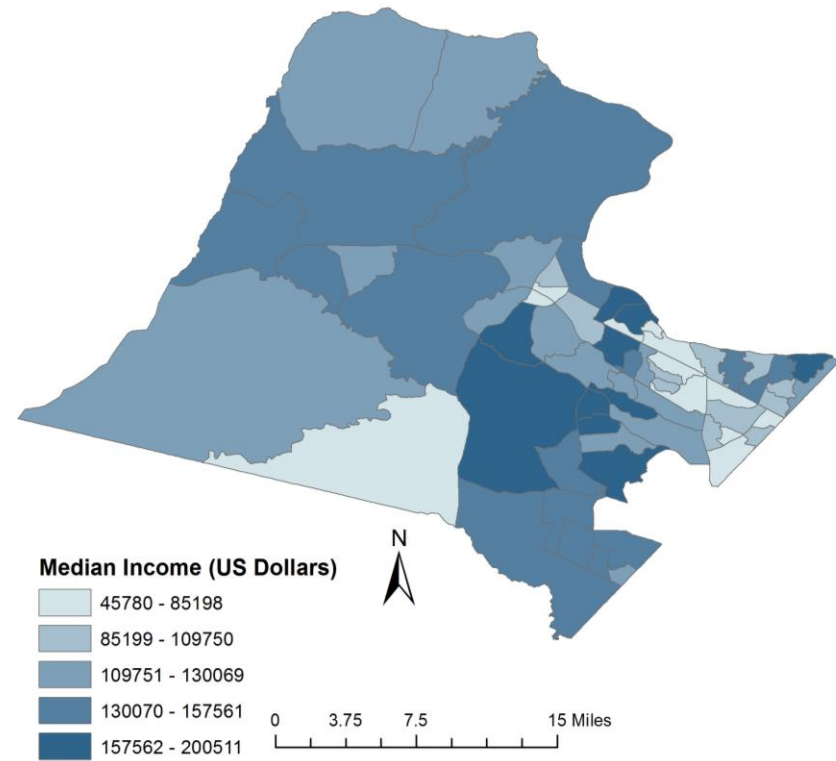


Figure 6: Median Income (US Dollars) in Loudoun County

Percent Poverty in El Paso County

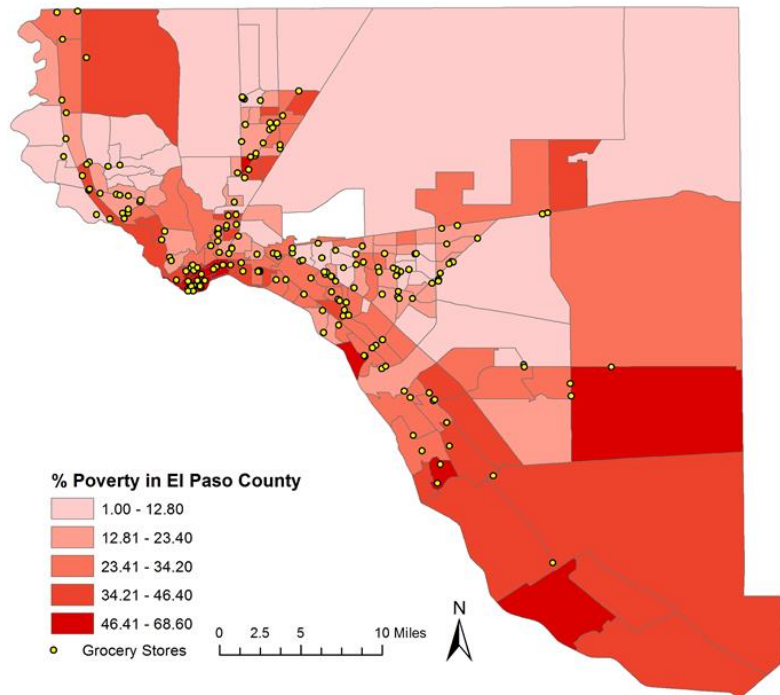


Figure 7: Percent Poverty in El Paso County

Percent Poverty in Loudoun County

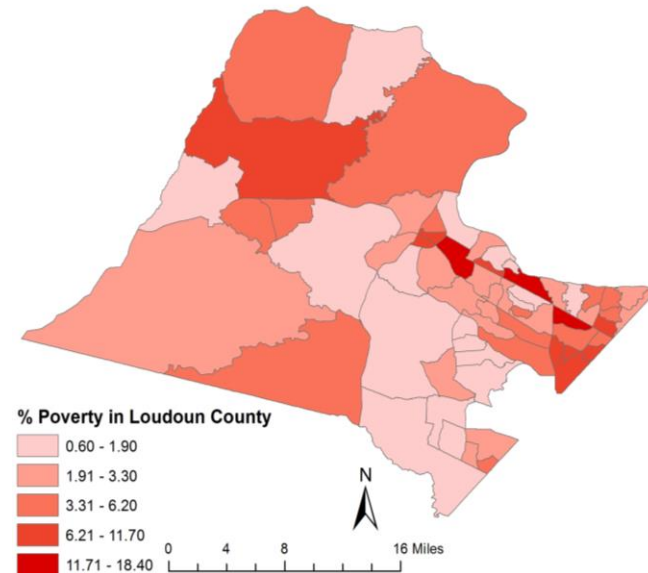


Figure 8: Percent Poverty in Loudoun County

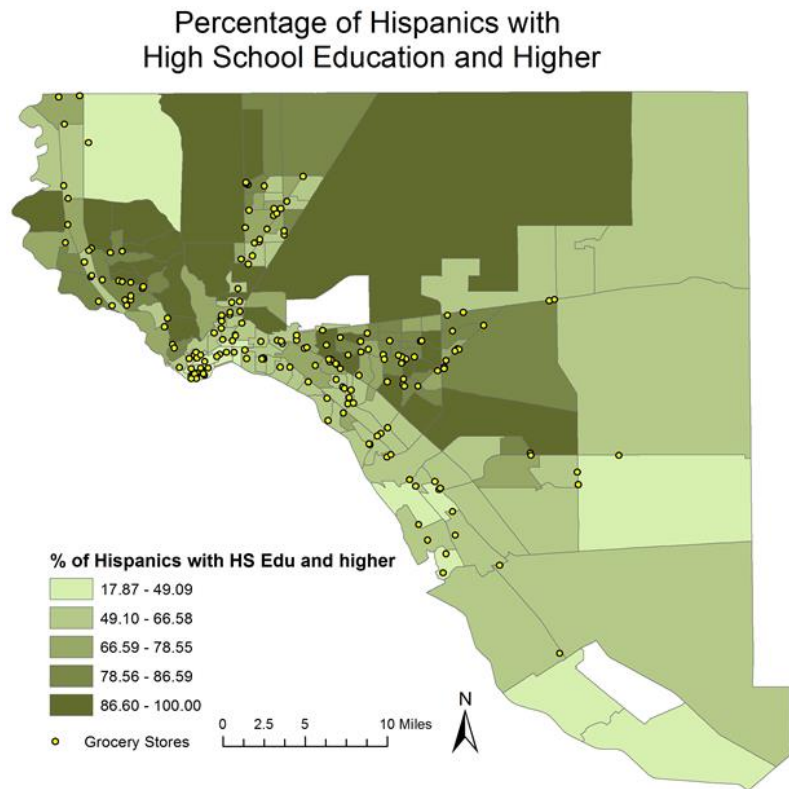


Figure 9: Percentage of Hispanics with High School Education and Higher in El Paso County

Percentage of Hispanics with High School Education and Higher in Loudoun County

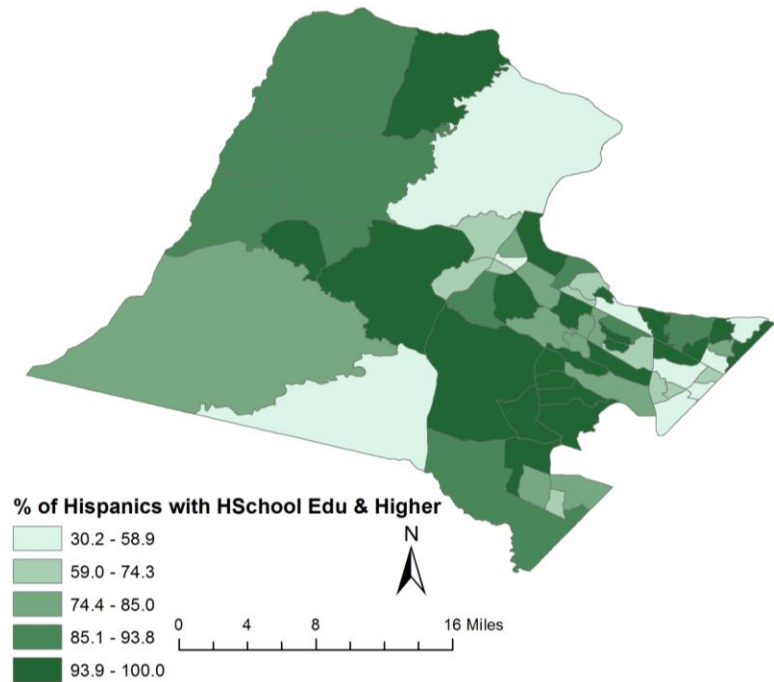


Figure 10: Percentage of Hispanics with High School Education and Higher in Loudoun County

Percentage of Non-Hispanics in El Paso County

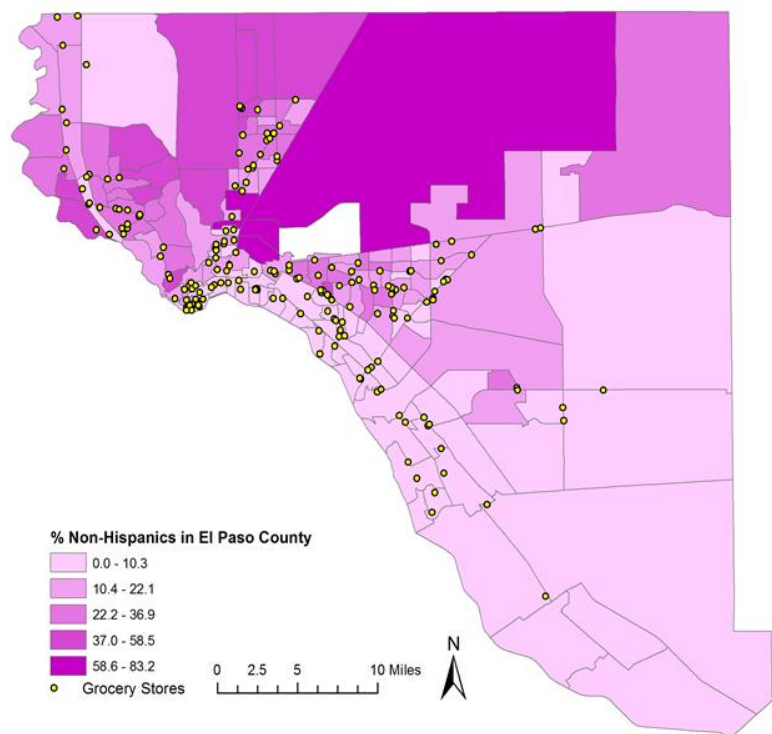


Figure 11: Percentage of Non-Hispanics in El Paso County

Percentage of Non-Hispanics in Loudoun County

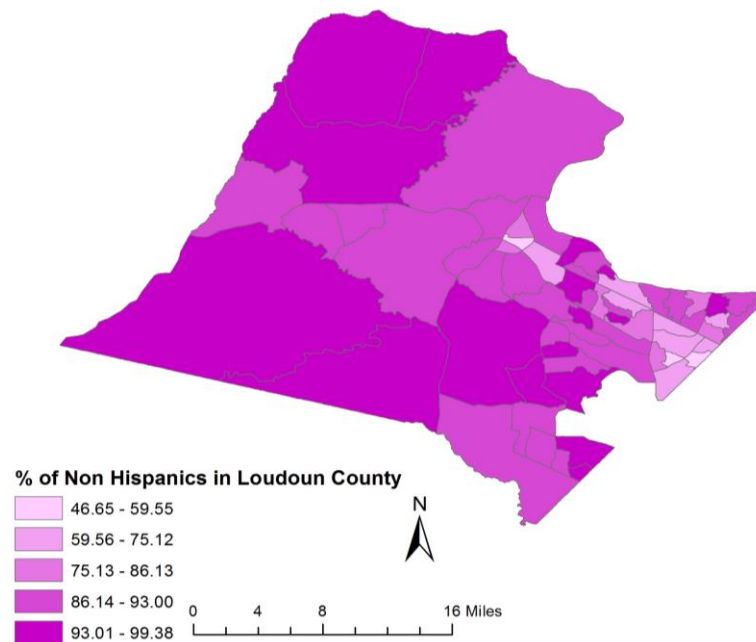


Figure 12: Percentage of Non-Hispanics in Loudoun County

Percentage of Limited English Speaking
Households in El Paso County

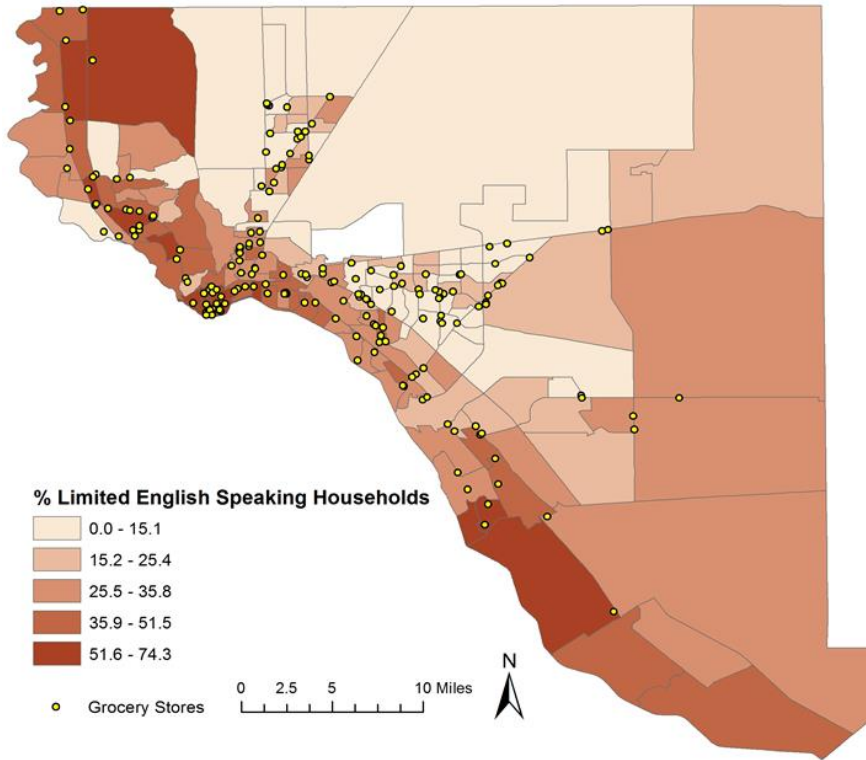


Figure 13: Percentage of Limited English Speaking Households in El Paso County

Percentage of Limited English Speaking
Households in Loudoun County

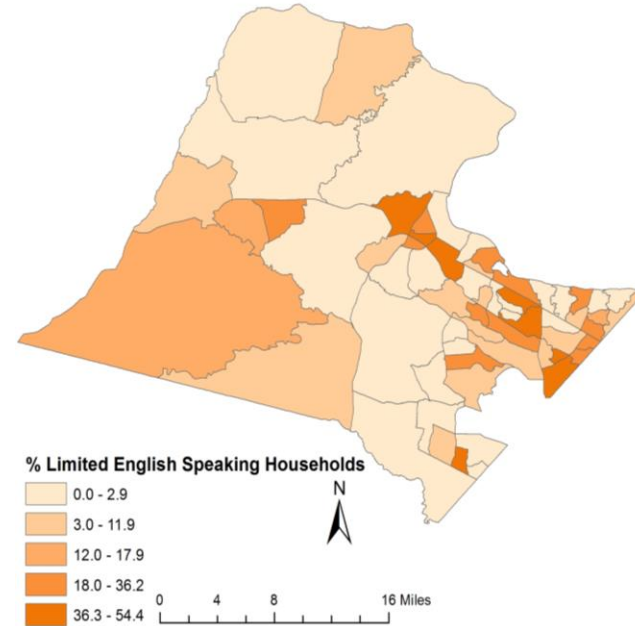


Figure 14: Percentage of Limited English Speaking Households in Loudoun County

Percentage of Hispanics with
Transportation in El Paso County

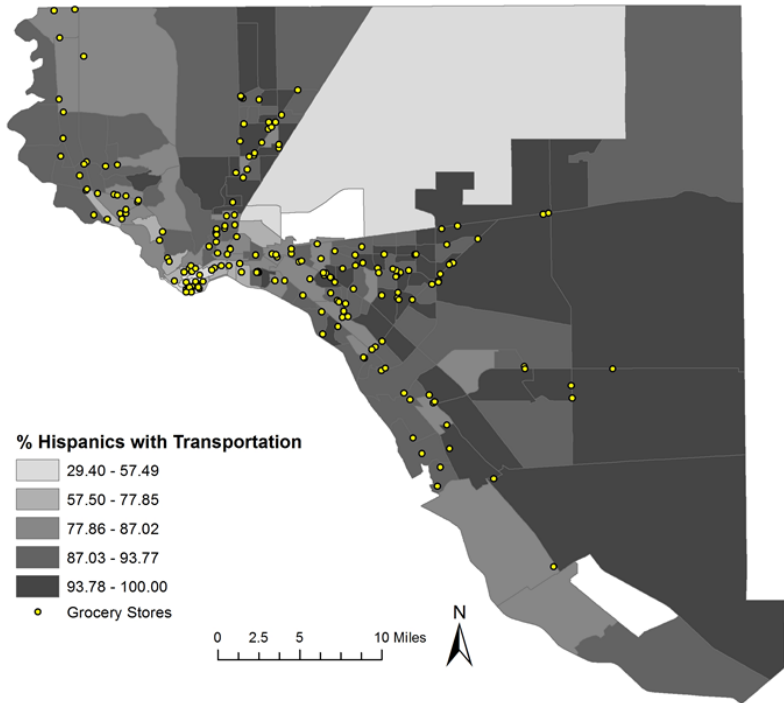


Figure 15: Percentage of Hispanics with Transportation in El Paso County

Percentage of Hispanics with Transportation
in Loudoun County

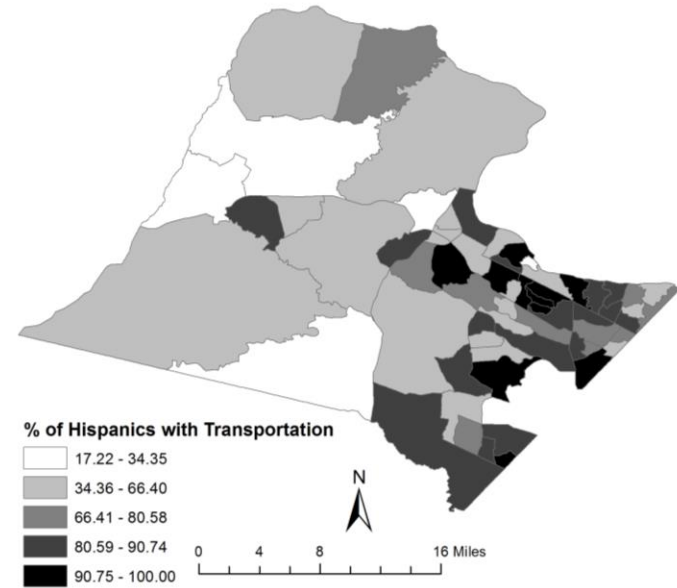


Figure 16: Percentage of Hispanics with Transportation in Loudoun County

Percentage of Whites with High School Education and Higher in El Paso County

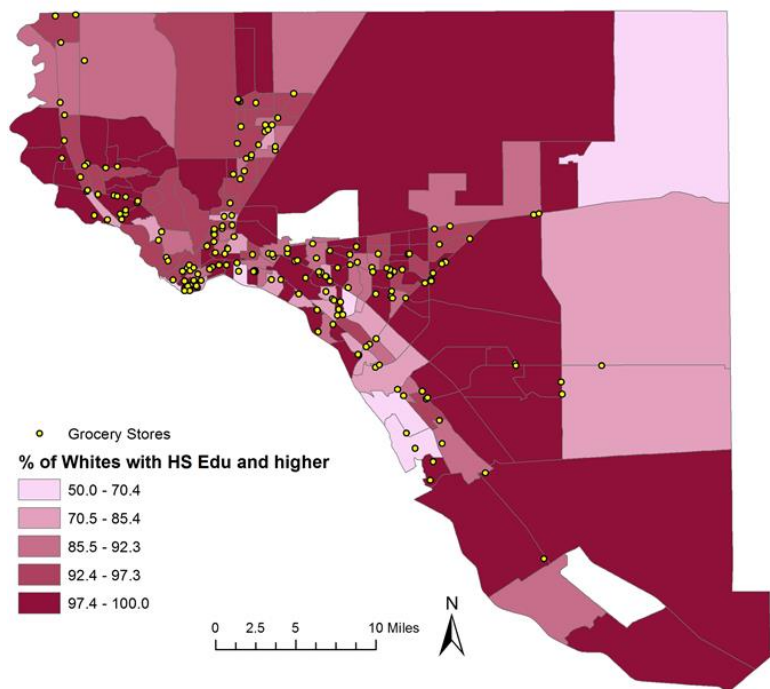


Figure 17: Percentage of Whites with High School Education and Higher in El Paso County

Percentage of Whites with High School Education and Higher in Loudoun County

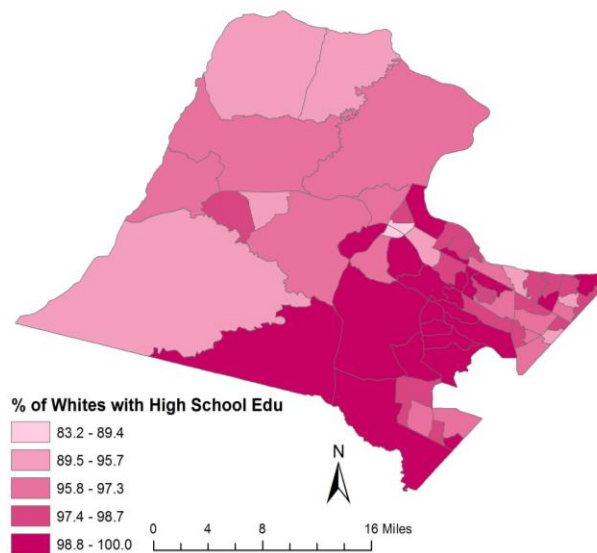


Figure 18: Percentage of Whites with High School Education and Higher in Loudoun County

Percentage of Non-Hispanics in El Paso County as is obvious from Figure 11 is concentrated in the Westside of the City of El Paso as well as the Ft. Bliss area. The Westside area of El Paso is comparatively more affluent than other parts of this County. Certain census tracts in the El Paso County are also predominantly Spanish speaking households. For example, census tracts in the Eastside and the Lower Valley bordering Mexico have almost 74% households that are predominantly Spanish speaking households.

In addition, it is obvious from the above GIS maps that certain areas of El Paso County, (especially in the Lower Valley, Socorro, San Elizario areas and the area adjoining the Dona Ana County of New Mexico) are predominantly Hispanic and have lower socio-economic attributes compared to the West side of El Paso City. ArcGIS is a great tool that helps understand these attributes as the visual representation of the data is a more robust method compared to just a table with number and other statistical parameters.

The demographic composition of Loudoun County, both from these GIS outputs and Census data, shows that Hispanics/Latinos only comprise about 14% of the whole population. The overwhelming population of the county is Caucasian. Census tracts in the eastern part of the county have high density of Hispanic/Latino population compared to the western census tracts which are Non-Hispanics Whites.

Loudoun County is the richest county in the United States. The GIS output showing the median income of the various census tracts is a testimony to that fact. Most of the census tracts have median income greater than \$ 100,000. The census tracts in the western and south central part of the county are the ones where we see the percent poverty rates less than 7%. Some of the census tracts where the Hispanic/Latinos are in a greater proportion in terms of population density are also the same census tracts where we see the median income less than \$ 100,000. The

GIS outputs suggest that upward of 70% of all the census tracts are very affluent areas in this county.

Census tracts with percentage of limited English speaking households are also the same as where we find high proportion of Hispanic/Latino population. In these census tracts, the percentage of limited English speaking households range from 36 to 54%. The percentage of Caucasians with high school education and higher in this county is also overwhelmingly very high. More than 83% of the White population has a high school education and higher. Majority of these people have at least completed four years of college and many of them have advanced professional degrees.

6.2 SCATTER PLOT MATRICES – RACE, POVERTY, MEDIAN INCOME:

This section focuses on the scatter plot matrices that were plotted for race, poverty, median income for both Hispanics and Non-Hispanics in both the counties. Scatter plot matrices are an effective tool to portray multiple data attributes in one figure. Another valuable aspect of such matrices are the histograms that also gets plotted while analyzing the data in ArcGIS.

Scatter plot matrices were plotted between the predominantly Hispanic and minority non-Hispanic groups versus Median Income, & Percent Poverty Rates for both El Paso County and Loudoun County. Figures 19 and 20 are the scatter plot matrices for poverty, race, and median income for both the ethnic groups in El Paso County, and Loudoun County, respectively. As is obvious from these figures, the Anglo-Saxon community in El Paso County are much better-off financially compared to the overwhelmingly Hispanic group.

Similar to the El Paso County, it is obvious that the overwhelmingly Caucasian community in most of the census tracts of Loudoun County are very affluent and have high median income. Figures 21 and 22 are the scatter plot matrix for the two races and median

income in El Paso County, and Loudoun County, respectively. The positive linear relationship between median income and Non-Hispanic White population is obvious from these scatter plot matrices.

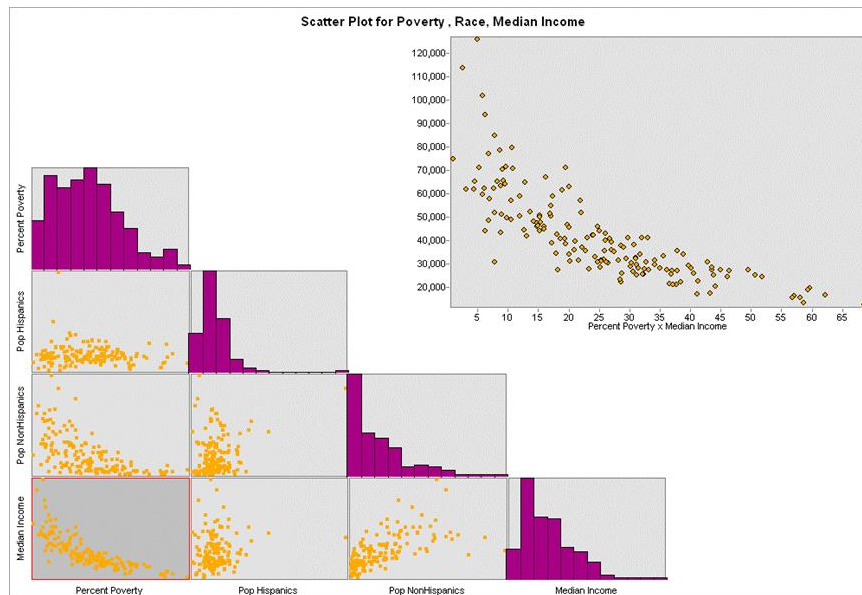


Figure 19: Scatter plot for Race, Percent Poverty and Median Income in El Paso County

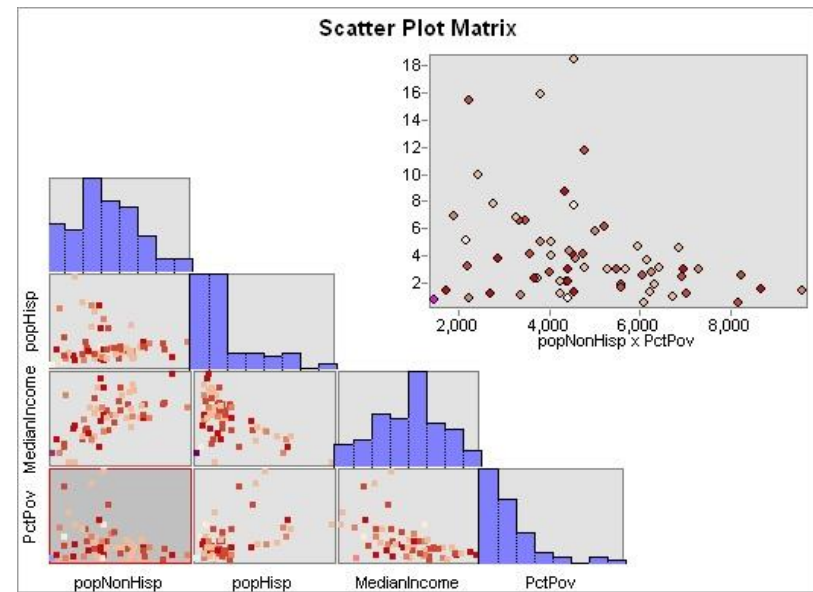


Figure 20: Scatter plot for Race, Percent Poverty and Median Income in Loudoun County

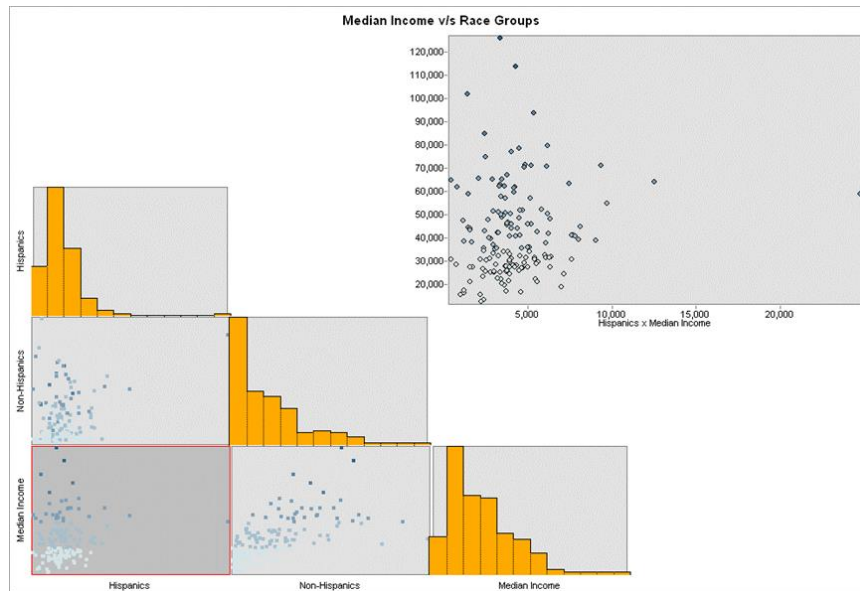


Figure 21: Scatter plot between Hispanics, Non-Hispanics and Median Income in El Paso County

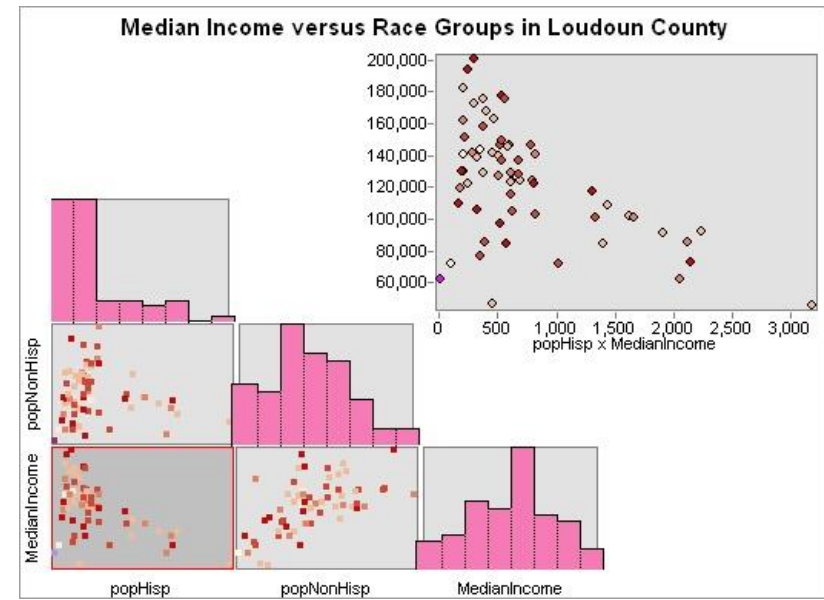


Figure 22: Scatter plot between Hispanics, Non-Hispanics and Median Income in Loudoun County

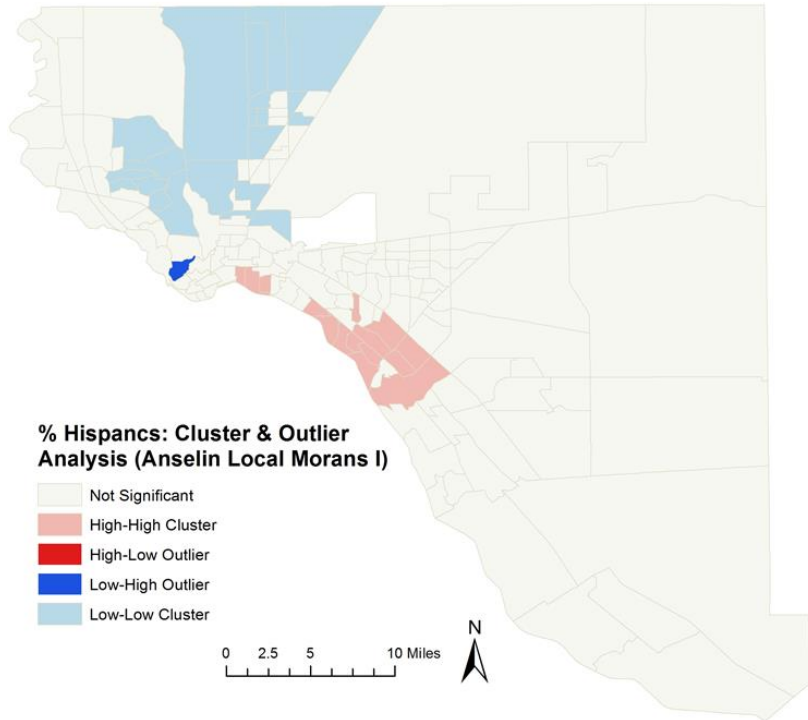
6.3 CLUSTER AND HOT-SPOT ANALYSIS (ANSELIN LOCAL MORANS I):

This section focuses on the Cluster & Outlier Analysis (Anselin Local Morans I) which was employed to examine the autocorrelation patterns of the two major ethnic groups (Hispanics and White Anglo-Saxons) in El Paso County and Loudoun County. Z-score results from this analysis will show the degree of spatial clustering for these two ethnic groups in both the counties. This analysis will help determine if the Hispanic and non-Hispanic clustering is random or not in both the El Paso County and Loudoun County.

The findings from these analyses are shown in Figures 23-26 below. Figure 23 focuses on the findings for the Hispanic group in El Paso County and Figure 24 for the findings for the Hispanic group in Loudoun County. Figure 25 corresponds to the Non-Hispanics Whites in El Paso County and Figure 26 corresponds to Non-Hispanic Whites in Loudoun County. Hispanic clustering is random in El Paso County compared to the 'High-Clusters' for Non-Hispanics as is obvious from the High-Low Clustering Report. The z-score for the Hispanics as is obvious from Fig 23 is 1.36 in contrast to 1.68 for the Non-Hispanic groups as is shown in Figure 25 in El Paso County. Statistically robust Hispanic clusters are obvious in the Lower Valley Region of El Paso. Non-Hispanic clusters are obvious in the affluent West side area of El Paso city.

Anselin Local Moran's I and spatial clustering report for both the ethnic groups were also plotted for Loudoun County. Figure 24 corresponds to the Hispanics in Loudoun County and Figure 25 to Non-Hispanic Whites. The spatial autocorrelation report for this analysis for both the groups suggest that the clustering of the ethnic groups is not random. The Moran's Index for Hispanics is 0.32 and the z-score is 4.812 ($p < 0.00001$). Given this z-score of 4.812, there is a less than 1 % likelihood that this clustered pattern could be the result of a random chance.

Cluster & Outlier Analysis (Anselin Local Morans I) for % Hispanics in El Paso County



High-Low Clustering Report

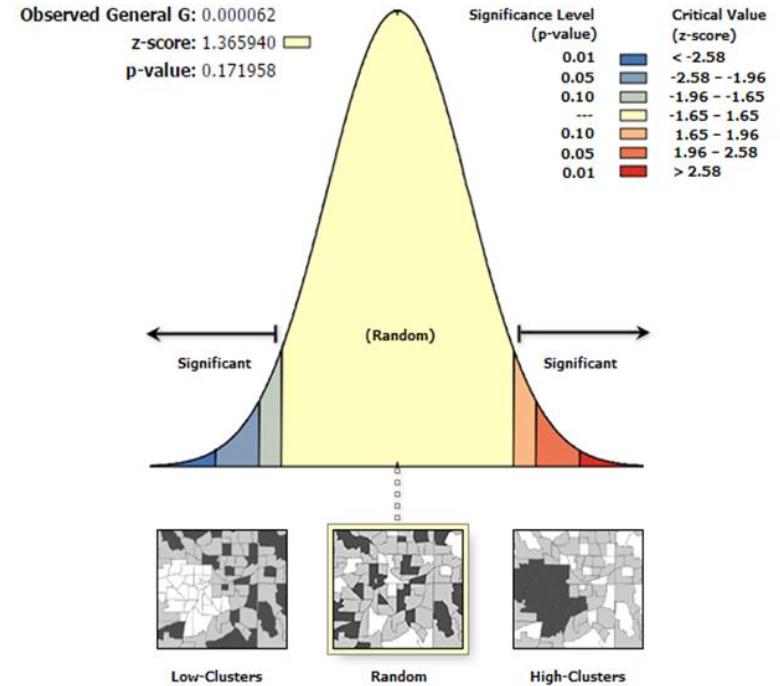


Figure 23: Cluster and Outlier Analysis (Anselin Local Morans I) and Spatial Clustering Report for Hispanics in El Paso County

Cluster & Outlier Analysis (Anselin Local Morans I) % Hispanics in Loudoun County

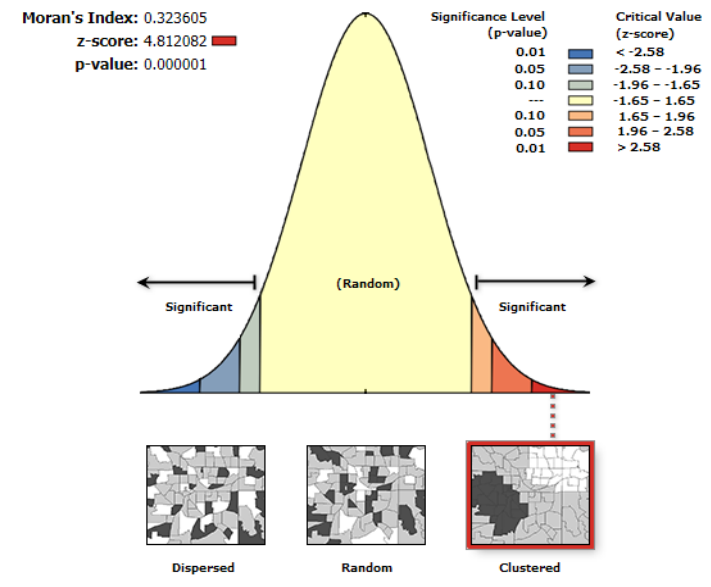
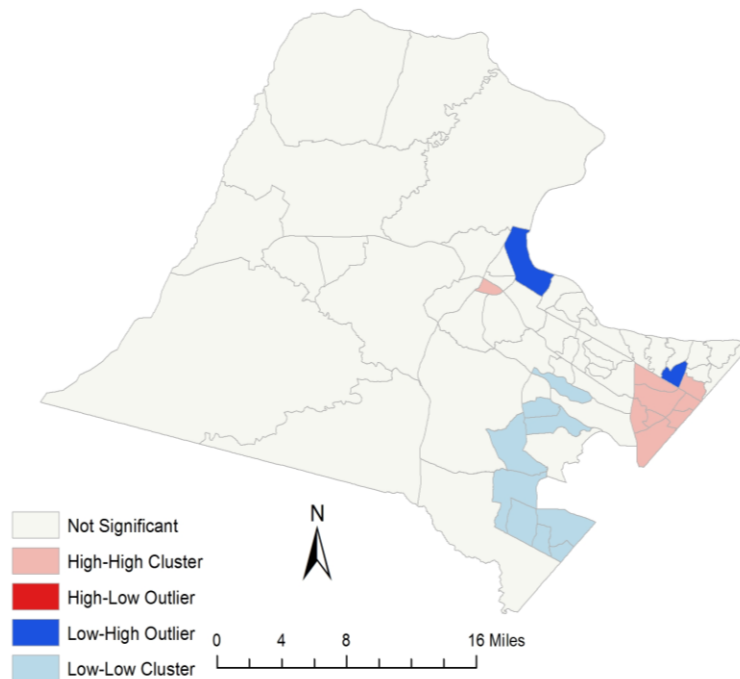


Figure 24: Cluster and Outlier Analysis (Anselin Local Morans I) and Spatial Clustering Report for Hispanics in Loudoun County

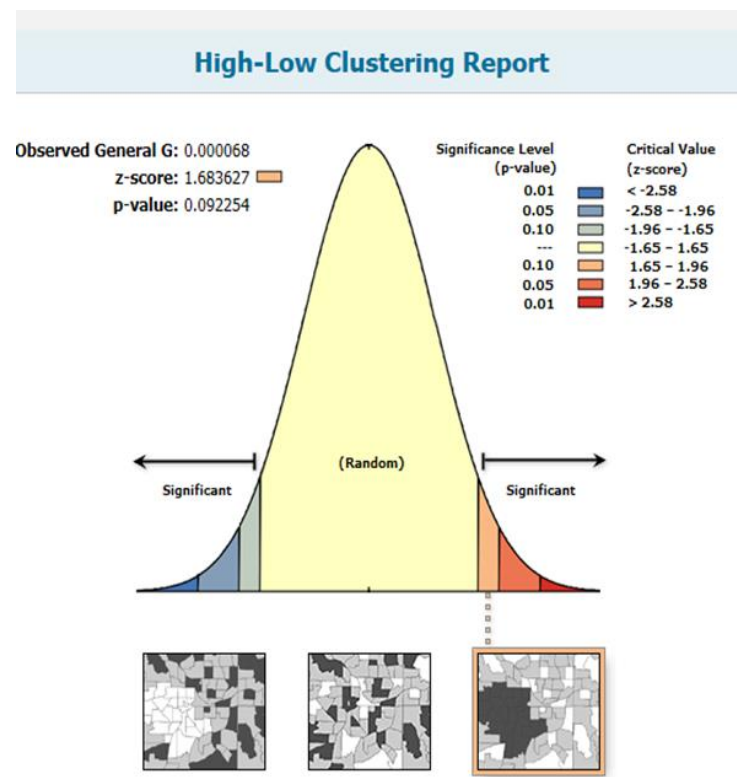
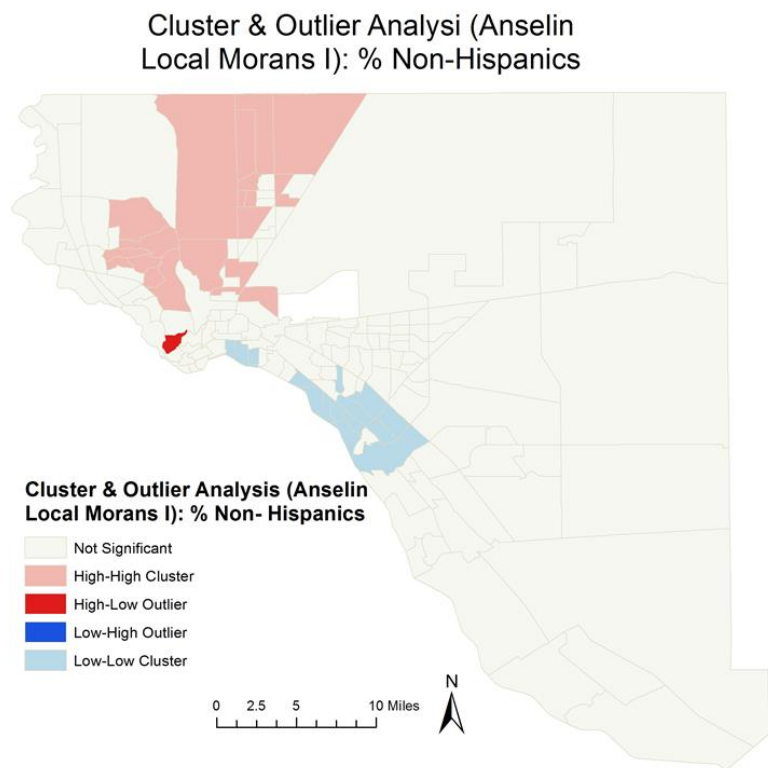


Figure 25: Cluster and Outlier Analysis (Anselin Local Morans I) and Spatial Clustering Report for Non-Hispanics in El Paso County

Cluster & Outlier Analysis (Anselin Local Morans I) % Non-Hispanics in Loudoun County

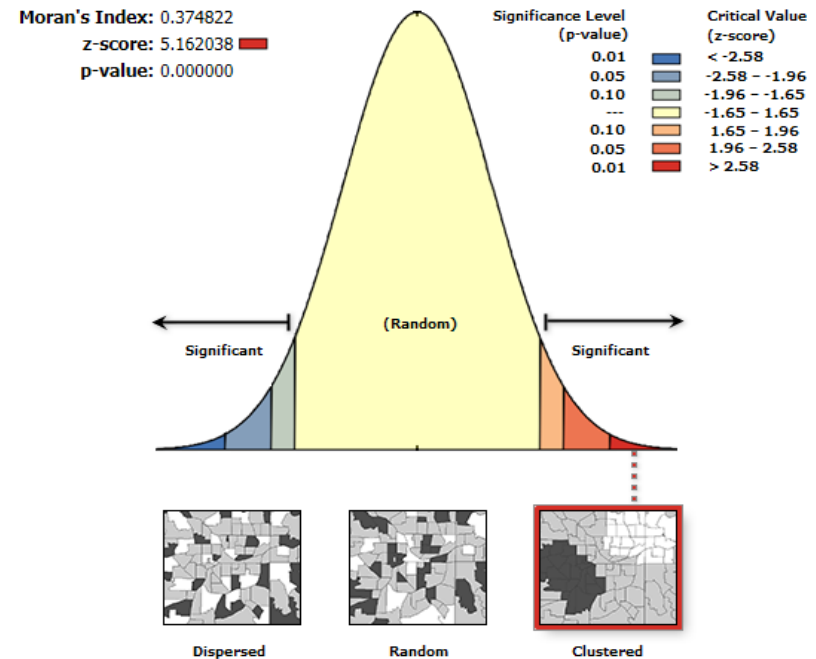
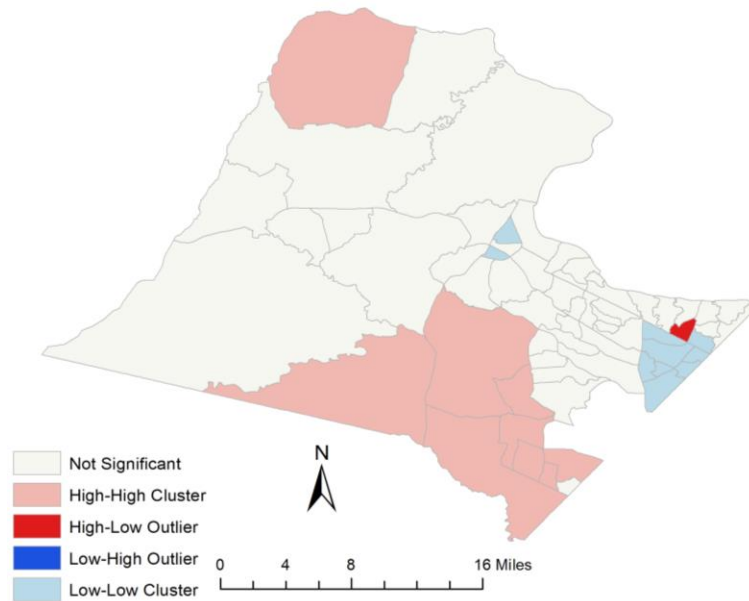


Figure 26: Cluster and Outlier Analysis (Anselin Local Morans I) and Spatial Clustering Report for Non-Hispanics in Loudoun County

In the same vein, the Moran's Index for Non-Hispanic Whites in Loudoun County is 0.375 and the z-score for this clustering is 5.15 ($p < 0.000001$). This z-score suggests that there is again less than 1 % likelihood that this clustered pattern of Non-Hispanics Whites could be the result of a random chance. High-high clusters of Non-Hispanic Whites in the lower half (southern and south –central) part of the county were indentified.

6.4 HOT SPOT ANALYSIS (GETIS-ORD GI):

Hot Spot Analysis (Getis-Ord Gi) was also undertaken to understand the distribution of Hispanics and Non-Hispanics in both the counties. 5000 m was the distance used for the analysis. The Z-scores were subsequently calculated that would help understand the robustness and statistical significance of the various ethnic groups in both the counties.

Figures 27 and 28 are the outputs for these analyses for Hispanics in El Paso County and Loudoun County, respectively. As is evident from these figures, the Lower Valley region of El Paso County has a statistically robust and significant concentration of Hispanics. The opposite is true for areas in the Ft. Bliss and other west side area of the El Paso County such as Coronado, Upper Valley etc. The Hot Spot Analysis (Getis-Ord Gi) was calculated for Non-Hispanics in El Paso County and Loudoun County. Figure 29 shows the result for the Getis-Ord Gi analysis for Non- Hispanic Whites in El Paso County and Figure 30 shows the Hot Spot analysis for Non-Hispanic Whites in Loudoun County. It is obvious from these two GIS outputs that the concentration of Hispanics and Non-Hispanics in the respective census tracts is statistically significant.

Hot Spot Analysis (Getis-Ord Gi):
% Hispanics in El Paso County

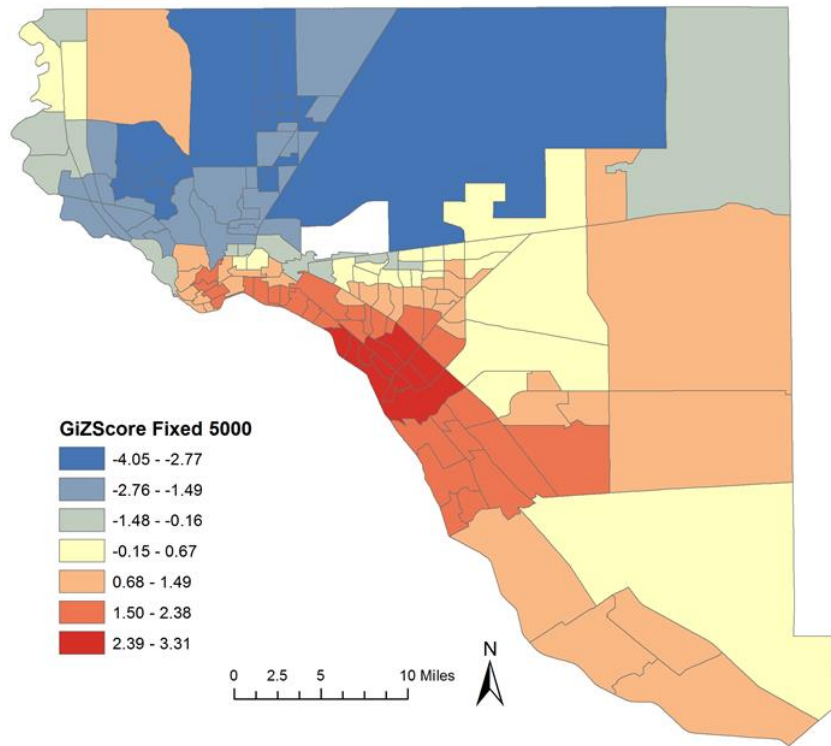


Figure 27: Hot Spot Analysis for Percentage Hispanics in El Paso County

Hot Spot Analysis (Getis-Ord Gi):
% Hispanics in Loudoun County

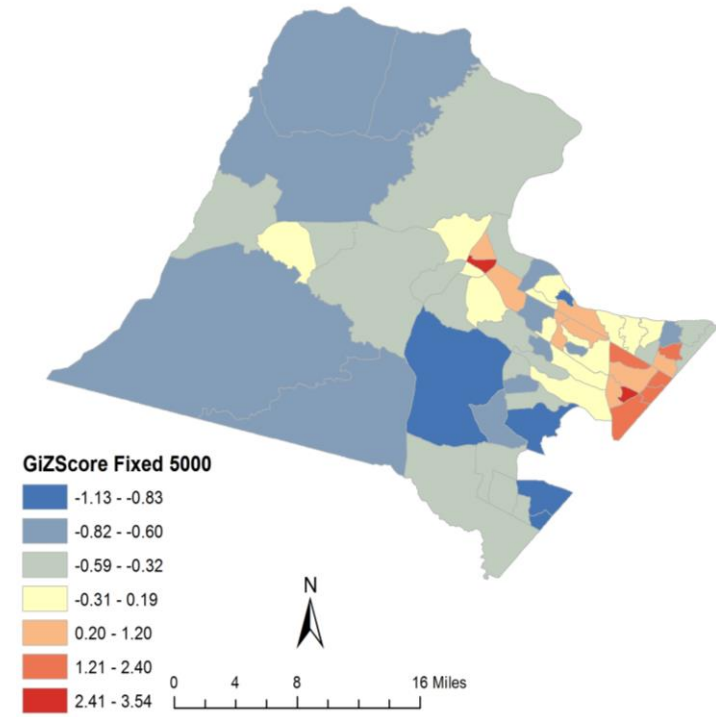


Figure 28: Hot Spot Analysis for Percentage Hispanics in Loudoun County

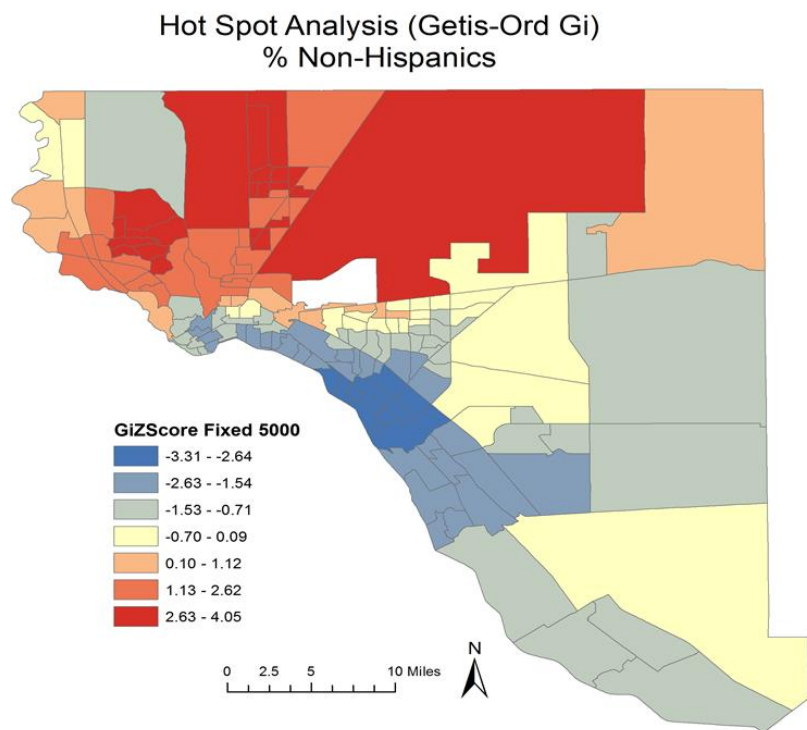


Figure 29: Hot Spot Analysis for Percentage Non- Hispanics in El Paso County

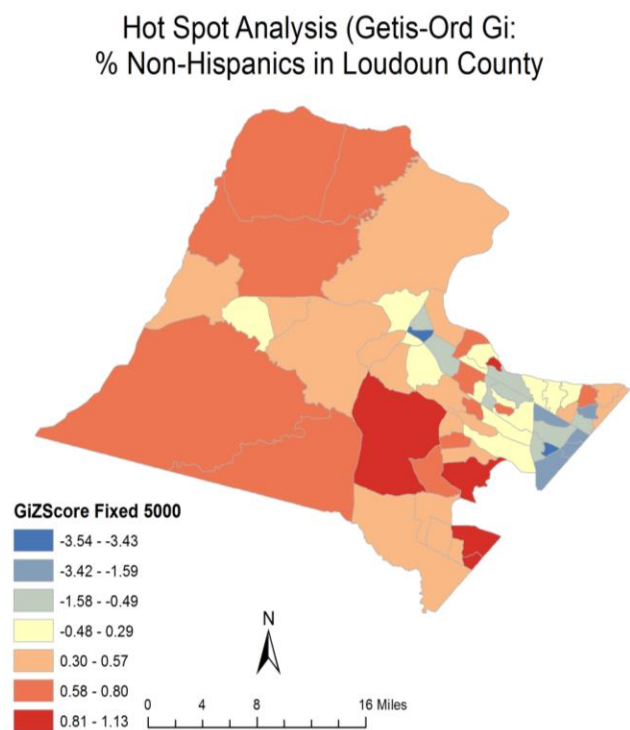


Figure 30: Hot Spot Analysis for Percentage Non-Hispanics in Loudoun County

6.5 GEOGRAPHICALLY WEIGHTED REGRESSION (GWR) ANALYSIS:

Geographically Weighted Regression (GWR) is an exploratory spatial analysis technique. It is an example of regression modeling with one independent variable and one dependent variable. The independent variable for this analysis is 'Percentage of Hispanics'. The dependent variables are the median income, percent poverty, Spanish as the primary language spoken, and high school education & higher. R^2 values were calculated for each census-tract. These values helped understand the influence of population concentrations on certain socio-economic attributes. Four models helped determine the relationship between each of the four dependent variables and independent variables.

Figures 31 and 32 are the GWR analysis outputs for percentage of Hispanics (independent variable) and median income (dependent variable), in El Paso County and Loudoun County, respectively. Similarly, Figures 33 and 34 are the GWR analysis outputs for percentage of Hispanics and percent poverty in El Paso County and Loudoun County, respectively. Figures 35 and 36 are the GWR analysis outputs for percentage Hispanics (independent variable) and Spanish as the primary language spoken (dependent variable), in El Paso County and Loudoun County, respectively. For 'High School Education and Higher' in El Paso County, the model was a good predictor with the R^2 values as high as 62.9%. This means the 62.9% of the variability in the dependent variable can be explained by the variability in the independent variable. The model performed weakly for 'Spanish as the Primary Language' with the highest R^2 value at only 36.7% for El Paso County. The R^2 values for the other two models (Median Income, and % poverty) were 41.1 and 44.8 %, respectively for El Paso County.

GWR: Percentage of Hispanics and Median Income

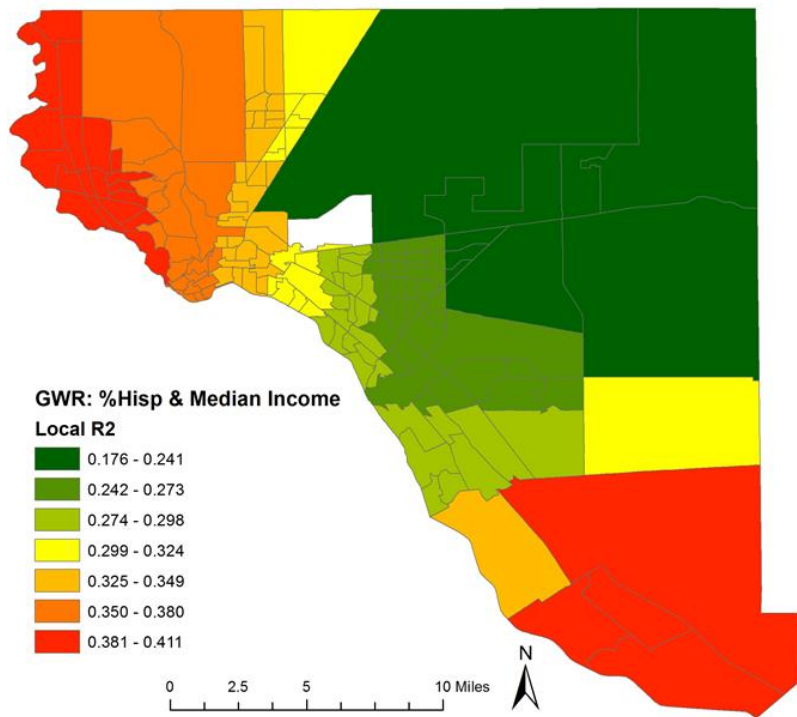


Figure 31: GWR Analysis- Percentage Hispanics & Median Income in El Paso County

GWR: Percent Hispanics & Median Income in Loudoun County

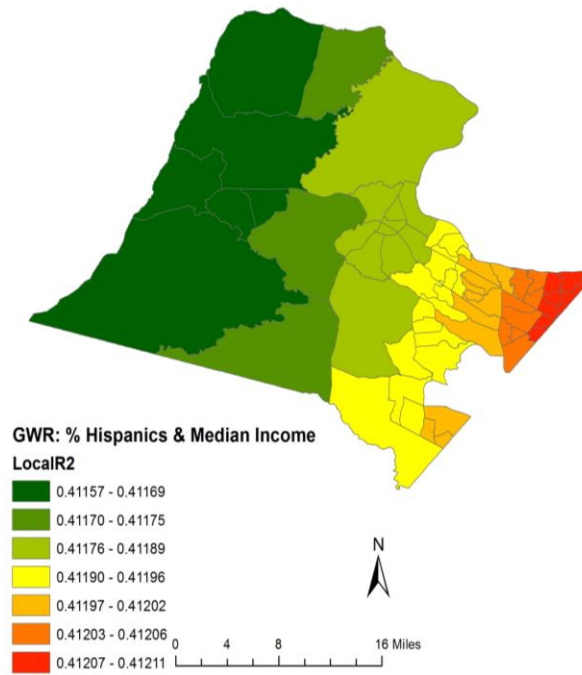


Figure 32: GWR Analysis – Percentage Hispanics and Median Income in Loudoun County

GWR: Percentage of Hispanics and Percent Poverty

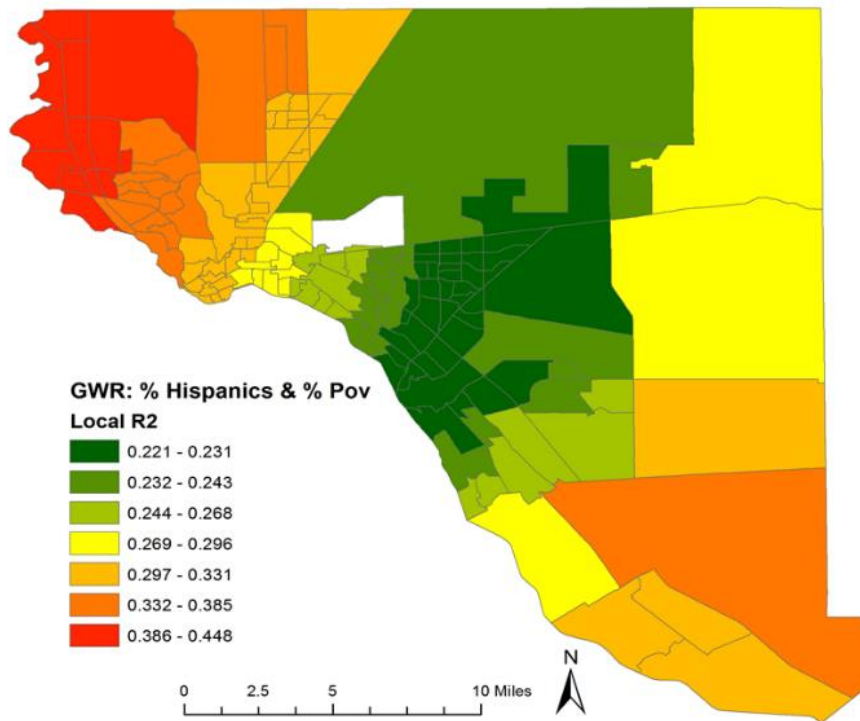


Figure 33: GWR Analysis- Percentage Hispanics & Percent Poverty in El Paso County

GWR: Percent Hispanics & % Poverty in Loudoun County

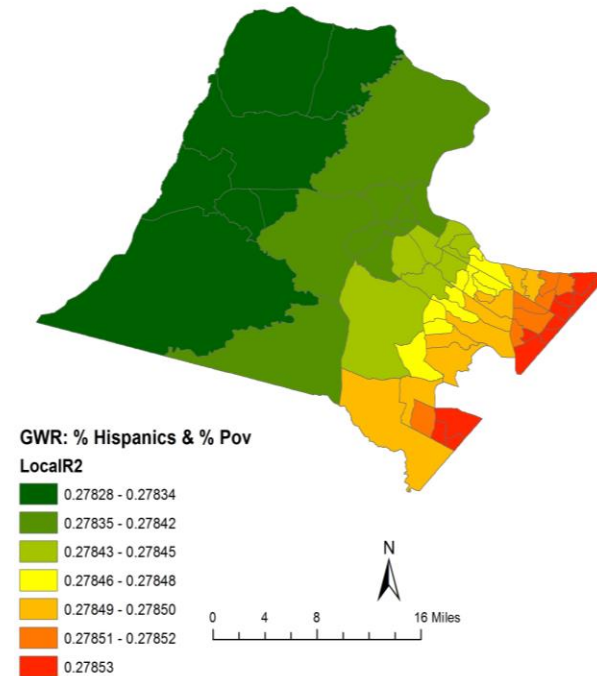


Figure 34: GWR Analysis – Percentage Hispanics and Percent Poverty in Loudoun County

GWR: Percent Hispanics &
Spanish as the Primary Language Spoken

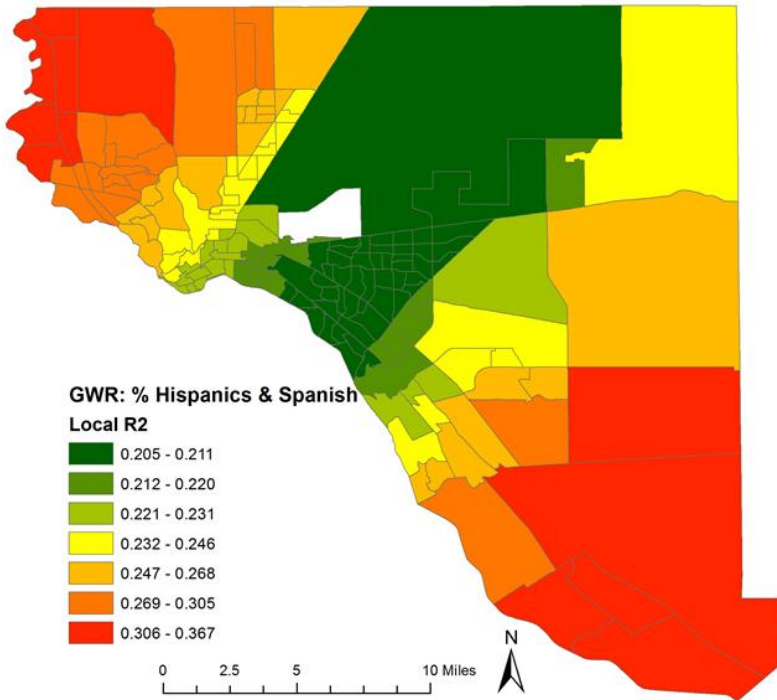


Figure 35: GWR Analysis – Percentage Hispanics & Spanish as the Primary Language Spoken in El Paso County

GWR: Percent Hispanics &
Spanish as Primary Language

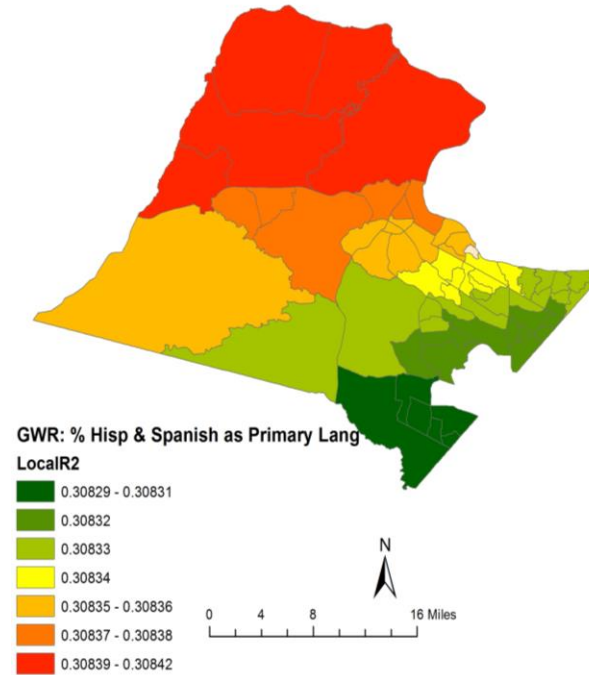


Figure 36: GWR Analysis – Percentage Hispanics & Spanish as the Primary Language Spoken in Loudoun County

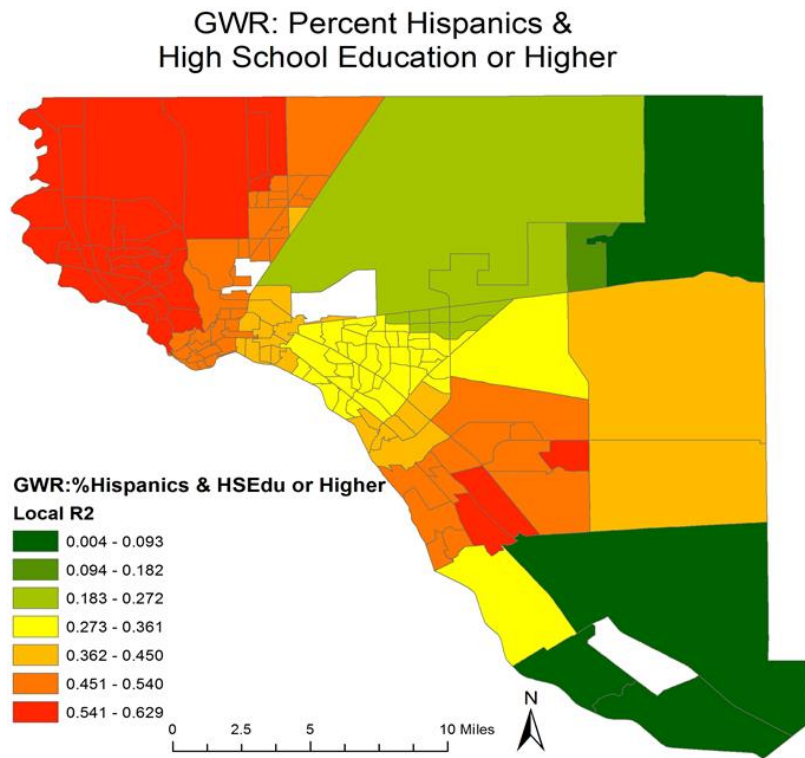


Figure 37: GWR Analysis – Percentage Hispanics & High School Education or Higher in El Paso County

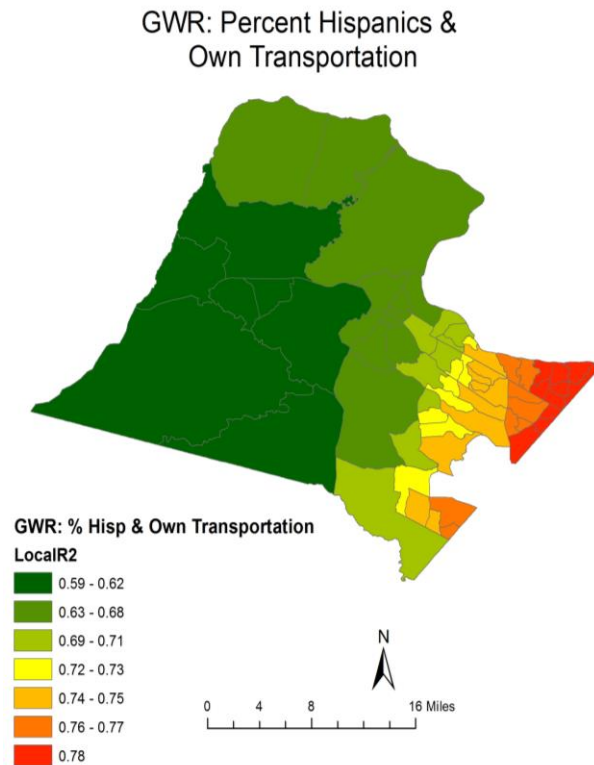


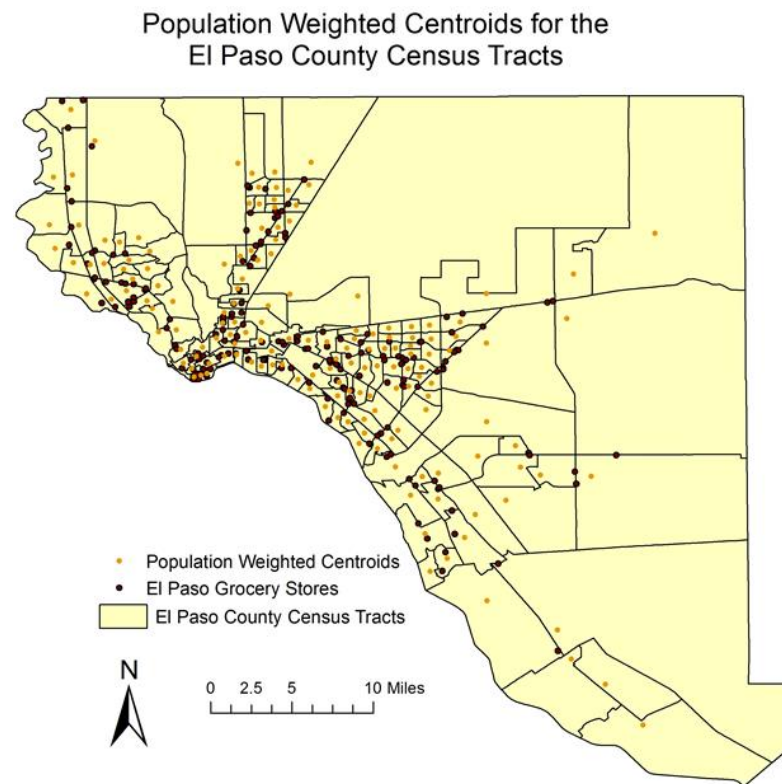
Figure 38: GWR Analysis – Percentage Hispanics and Own Transportation in Loudoun County

Figures 37 is the GWR analysis output for percentage of Hispanics (independent variable) and Spanish as the primary language (dependent variable) for El Paso County. The GWR analysis output for percentage of Hispanics (independent variable) and transportation (dependent variable) for Loudoun County is shown in Figure 38. For ‘transportation’, the model was a good predictor with the R^2 values as high as 78.0%. This means the 78% of the variability in the dependent variable can be explained by the variability in the independent variable. The model performed weakly for ‘Spanish as the Primary Language’ with the highest R^2 value at only 30.8% for Loudoun County. In addition, the model also performed very weakly for ‘Percent Poverty’ with the highest R^2 value at 27.8% for Loudoun County. Similarly, the R^2 values for Median Income model (Median Income, and % poverty) was 41.2% for Loudoun County.

6.6 BUFFER ANALYSIS FOR FOOD DESERT DETERMINATION:

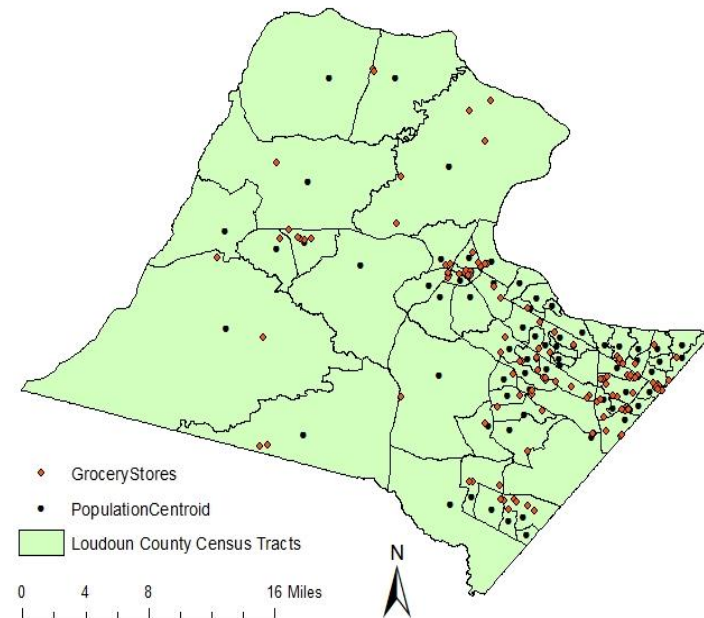
For this section of the thesis, population-weighted centroids were obtained from the US Census Bureau. Grocery stores (geo-coded x, y locations), bus stops and major arterial roads were also be added to the GIS data frame for both the counties. Population-weighted buffers (one mile) were created in order to determine the census tracts that do not have a grocery store. Buffers were also created around the major arterial roads (0.25 miles) and bus stops (0.25 miles) for El Paso County.

Figures 39 and 40 shows the Population Weighted Centroids in each census tract in El Paso County and Loudoun County, respectively. Figure 41 shows the major arterial roads and bus stops in the El Paso County.



**Figure 39: Population Weighted Centroids for
El Paso County**

Population Weighted Centroids for Loudoun County



**Figure 40: Population Weighted Centroids for Loudoun
County**

Bus Stops and Major Arterial Roads

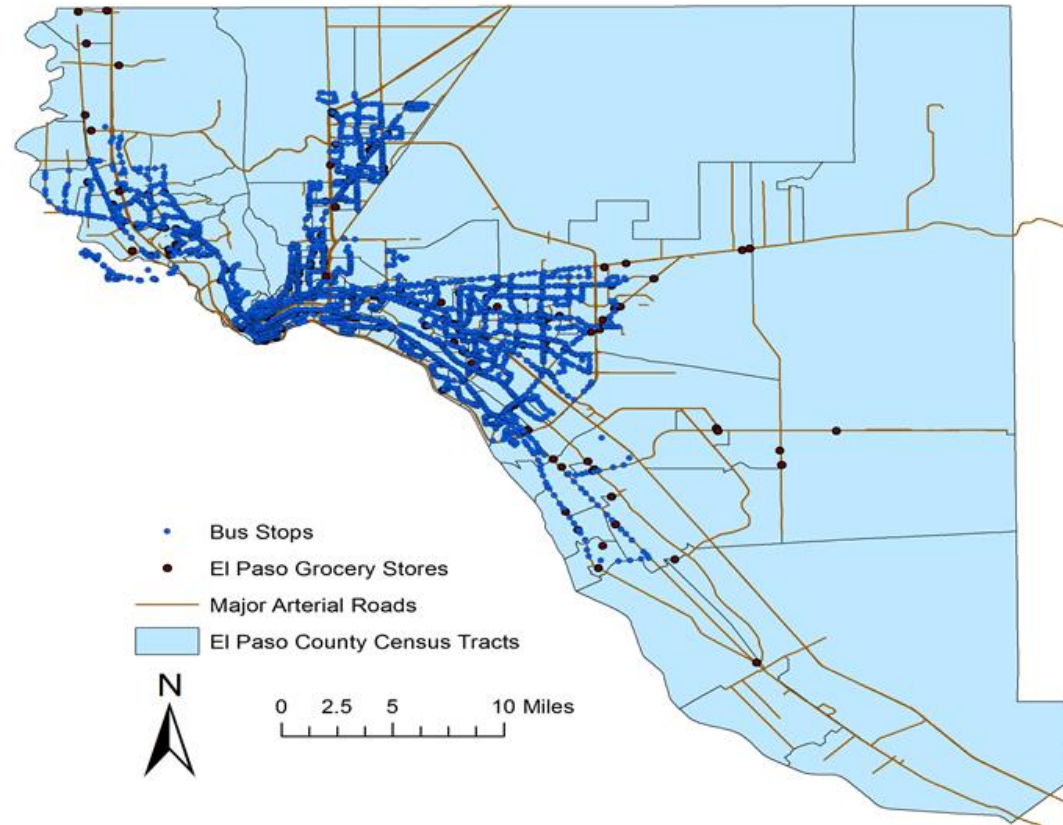


Figure 41: Major Arterial Roads and Bus Stops in El Paso County

Bus Stop Buffers (0.25 miles) and Grocery Stores

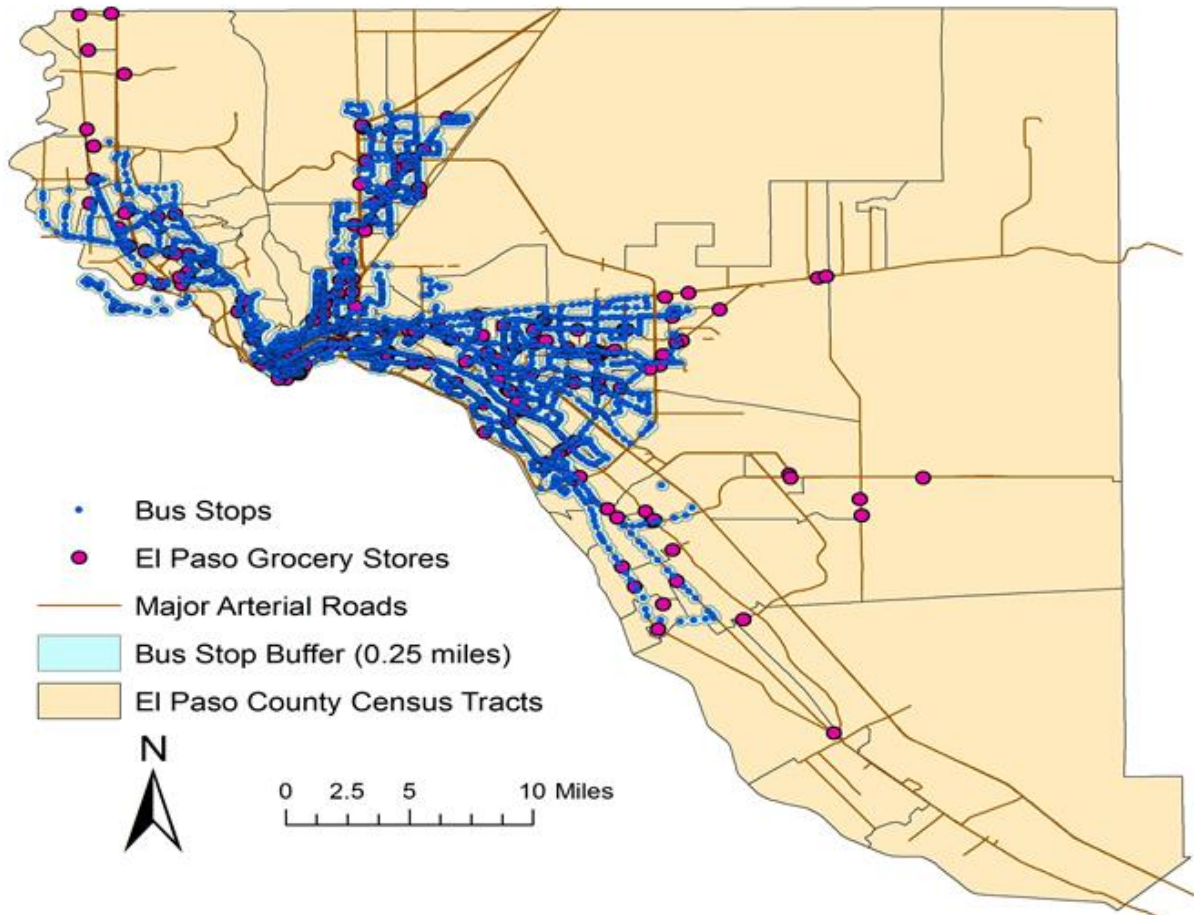


Figure 42: Buffer of 0.25 miles around Bus Stops in El Paso County

Major Arterial Road Buffers (1/4 mile) and Grocery Stores

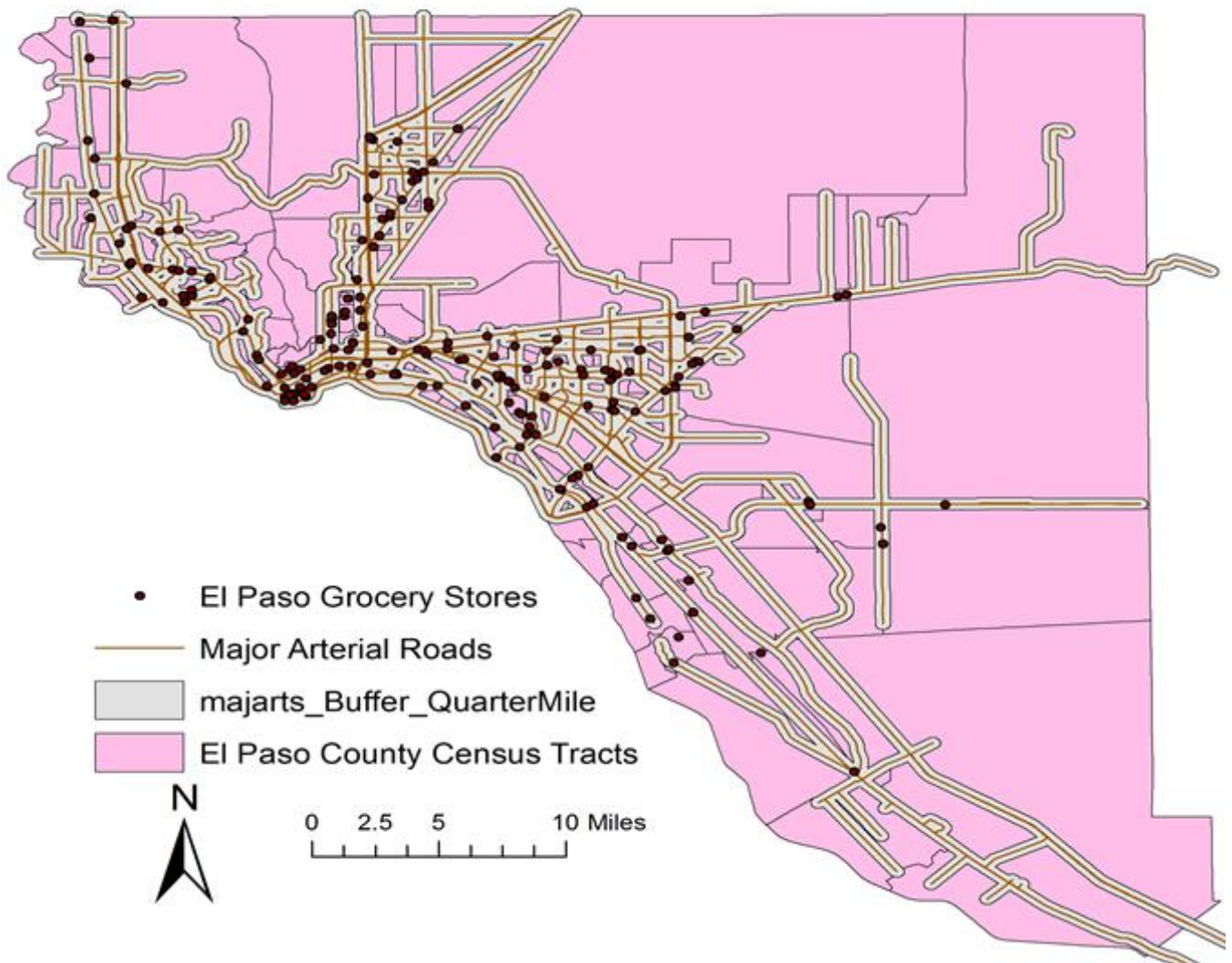
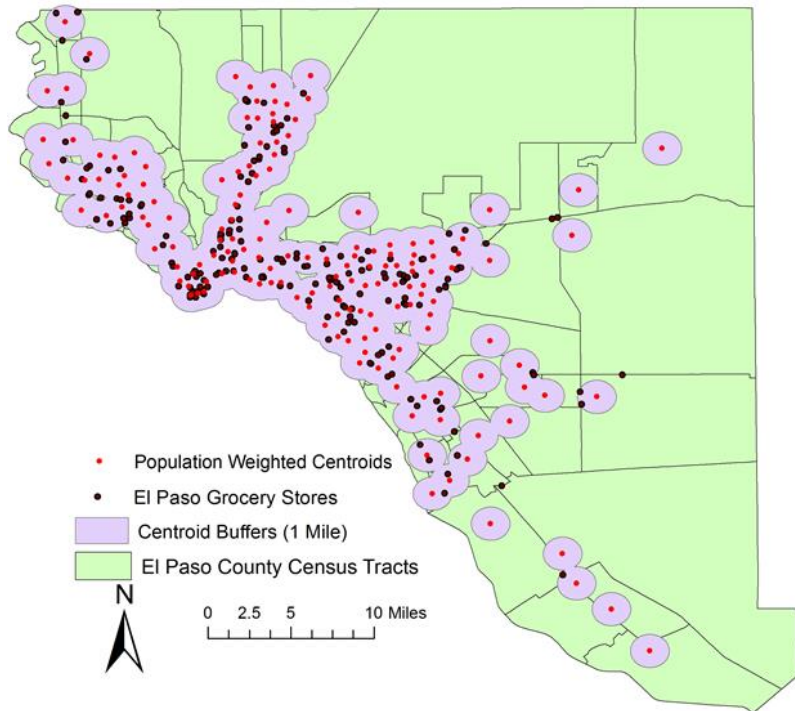


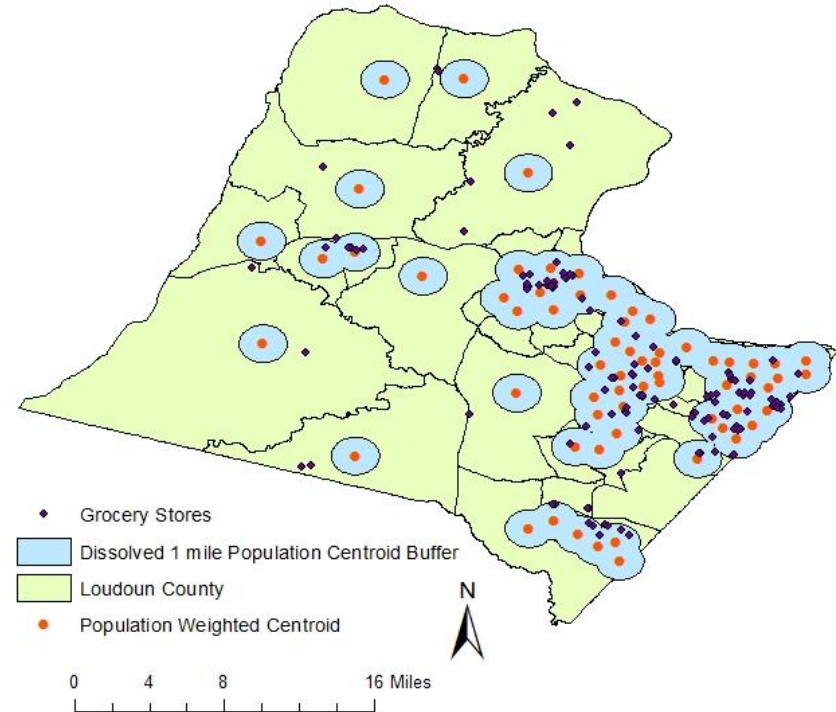
Figure 43: Buffer of 0.25 miles around Major Arterial Roads in El Paso County

Populaton Weighted Centroid Buffers (1 mile)
after Dissolving and Grocery Stores



**Figure 44: Population Weighted Centroids with a
1 mile Dissolved Buffer in El Paso County**

Dissolved 1 mile Population Centroid Buffer



**Figure 45: Population Weighted Centroids with a
1 mile Dissolved Buffer in Loudoun
County**

Dissolved 1 mile Population Centroid Buffer & All Road Network in Loudoun County

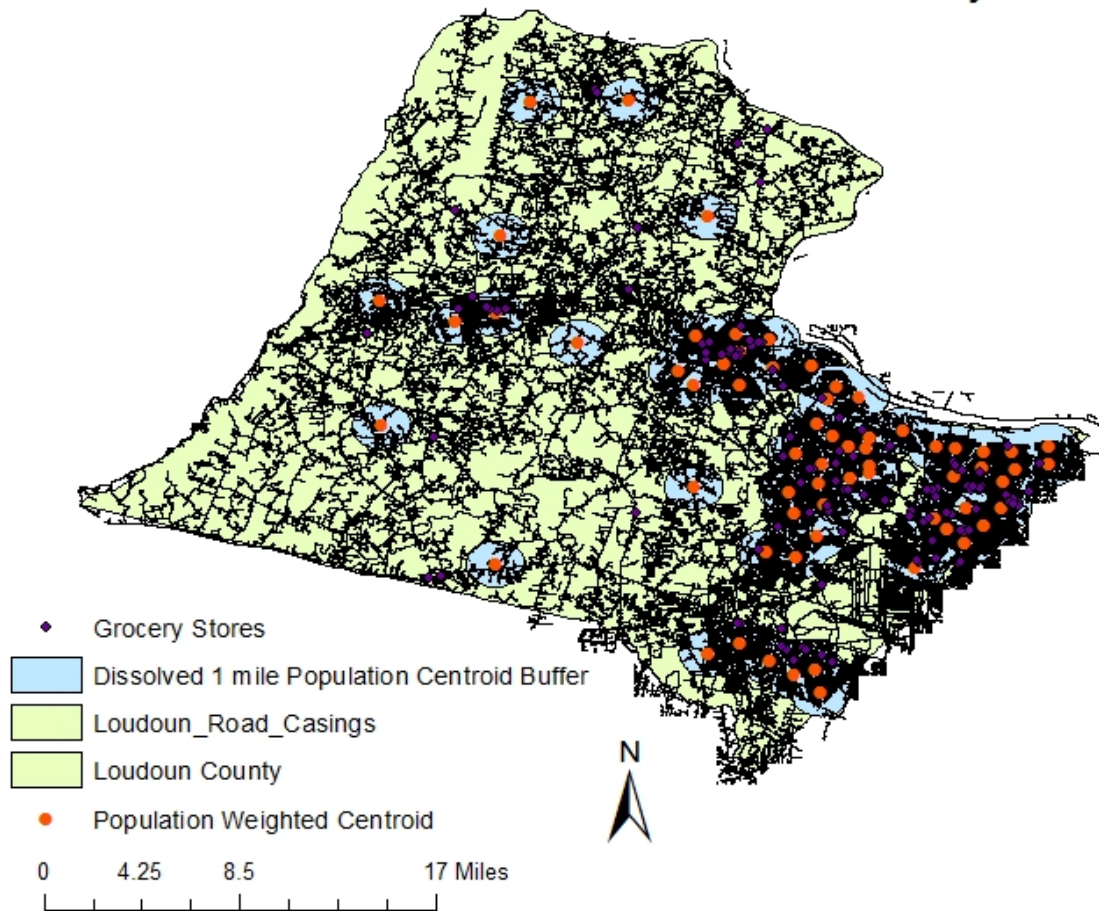


Figure 46: Road and Street Networks and Dissolved 1 mile Buffer Population Weighted Centroids with Grocery Stores in Loudoun County

Figure 42 shows the 0.25 miles buffer around the bus stops in each of the census tracts of El Paso County. Figure 43 shows the 0.25 miles buffer around the major arterial roads in El Paso County. The *rationale* behind these buffer distances is that if a person has to traverse more than 0.25 miles to reach a bus-stop or if the grocery store is located at a distance of one mile or more, then that person is an inhabitant of a food desert. The quarter of a mile distance was chosen

because it typically takes about five minutes to traverse that distance by foot (Atash, 1994; Gordon et al., 2011).

For all the activities in this sub-section, apart from buffering, dissolving was also done to finally identify the census tracts that are devoid of any grocery stores. From this analysis, it is obvious that certain areas in the south-east, eastern, and north-west part of El Paso County could be categorized as ‘Food Deserts’.

Figures 44 and 45 show the population weighted centroid dissolved buffers and locations of grocery stores in El Paso County and Loudoun County, respectively. A one mile buffer was also incorporated around the population weighted centroids in both these figures. The ‘Dissolve’ geoprocessing feature in GIS was used to create Figure 44 and 45. Figure 46 also captures the road and street network along with the grocery stores, and the population centroids in Loudoun County. The lines in black are the street and road networks in the Loudoun County. These GIS outputs give us a clear idea of food deserts in Loudoun County. Some census tracts in the north-central, north-eastern, and south-western part could be classified as ‘Food Deserts’.

6.7 DISCUSSION

This section of the thesis focuses on the important findings and the important underlying message that is derived from all the GIS analyses. When the idea for this research work was conceived, it was felt that a comparative assessment between two varying different counties in different states would accentuate the complexities associated with the determination of food deserts in the urban landscape of 21st century United States. Given the fact that El Paso County is a vibrant bi-cultural, bi-lingual area on the U.S.-Mexico border, it was felt imperative that the ‘Food Desert’ scenario here be contrasted with the richest county in the United States. Loudoun County in Virginia, as explained earlier, has the highest median income than any other county.

Also, the main focus of comparison in terms of these two counties is the Hispanic/Latino population. It is prudent to mention here, however, that the term ‘Hispanic/Latino’ has many connotations in literature and the ultimate interpretation of any analyses needs to be taken into consideration by well defining the contours of the definition of this term.

In El Paso County, the majority of the Hispanic/Latino population is of Mexican-American origin or descent. However, this may not be true for Loudoun County as the Hispanic/Latino population in this county may comprise of populations from Central and South America as well as the Caribbean in addition to population group of Mexican descent. The health complications that arise from non-availability of fresh fruits and vegetables in any census tract for a given population is dependent on a variety of factors and may vary within all these Hispanic/Latino groups. The analyses conducted in this research work, therefore, and the subsequent conclusions and suggestions should be interpreted with this inherent understanding.

Based on the statistical analyses conducted for both the counties, it is obvious that in El Paso County the Hispanic/Latino population is dominant in all the census-tracts as compared to the census-tracts of the Loudoun County. The Upper Valley and West side region and Ft. Bliss area in the North-east part of the city of El Paso has a more diverse and mix population. Both the Caucasian and Mexican-American groups in the Upper valley region and the west side region of the El Paso belong typically to the middle-class and upper-middle class (affluent) section of the society with at least access to personal vehicle. Also, the west side region of El Paso County has a wide variety of Grocery stores such as Whole Foods, Sprouts, Albertsons, Walmart and Sam’s Club, and Food King in addition to some ethnic grocery stores. Most of these stores are also situated on the main arterial roads such as Mesa Street which is serviced by a wide variety of Sun Metro buses – which is the local mode of public transportation in the city of El Paso. However,

the Lower Valley Region (Socorro, San Elizario, and Tornillo areas) of El Paso County are indeed 'Food Deserts' and majority of the local populace also belong to the lower socio-economic segment of the society.

The same is not true for Loudoun County. Loudoun County has a very affluent population and it can be said with surety that majority of the people living in this county would have access to their personal vehicles. The Hispanic/Latino population, which is just around 13% of the whole county population, may be the residents of few census tracts which could be classified as Food Deserts. However, it is also important to mention here that in most ethnic immigrant communities in the United States the social and familial bonding are very robust. As such, individuals without any public transportation could perhaps car pool with some of their relatives or friends and fulfil most of their grocery shopping needs.

The scatter plot analyses results also portray the ground realities that the more affluent Caucasian population in both the counties have a high median income compared to the Hispanic/Latino population. The Cluster and Hot-Spot Analyses also corroborate the fact that certain census tracts in both the counties have statistically significant concentrations of both the Hispanic/Latino and Caucasian population and the results are not anecdotal or apocryphal. The Geographically Weighted Regression (GWR) analyses also helped understand the nuances of the role played by the various socio-economic factors towards the subsequent existence of food deserts in both the counties. The dissolved and buffer analyses for the determination of food deserts in both El Paso and Loudoun County helped fulfil the main aims of the determination of food deserts in these counties.

Finally, the two counties studied in this research work could be considered as urban areas and the complexities associated with food deserts in urban and rural areas of the United States is

a topic worth exploring in future studies. For example, certain rural counties in the states of Alabama, Mississippi, and other states in the Deep South are prime example of food deserts. The local populace in those regions may, therefore, bear the huge brunt of high shopping costs associated with grocery shopping due to long distance traveling (gas, and time related factors) and also the limitations in the choice of fresh fruits and vegetables. Future studies should definitely look into the contrast between the urban and rural counties while determining food deserts especially in the U.S.-Mexico border region.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

Determination of Food Deserts in any urban or rural environment is a complex procedure and various factors play an important role. In this project, various socio-demographic and economic attributes were studied to help assess their influence on probably Food Deserts. Based on the various analyses conducted in this project, it is apparent that low per capita income, poverty rate, educational attainment, and language preference may increase the number of census tracts which could be officially classified as a Food Desert. Areas in the south-west, eastern, and north-west part El Paso County have some Food Deserts. Similarly, certain census tracts in the north-central, north-western and south-western part of Loudoun County in the Virginia Commonwealth could be considered as food deserts. Transportation was not an issue in terms of access to grocery stores for the Hispanics in Loudoun County. However, areas such as Clint, San Elizario, Socorro, Tornillo in the El Paso County do not have a robust public transportation network and this can impede people's access to grocery stores.

There are some limitations to this project which warrant mention here. Important metrics such as obesity rates, employment rates, poverty rates, food pricing information, and food quality were not used. Future analyses should also incorporate these in exploratory analysis. Also, food preferences are a matter of choice and some individuals may still adopt unhealthy eating habits in spite of the availability of fresh fruits and vegetables. It would be a prudent idea to compare the findings from the El Paso County and Loudoun County to other food desert areas especially in the Atlanta Metropolitan Region, Chicago, and the New Orleans Region, especially in future research. The results of the GIS analysis from El Paso County and Loudoun County also contrasted significantly.

It is prudent to mention here that even if a typical urban landscape is dotted with grocery stores but if the residents in a typical neighborhood do not have access to viable transportation then this could act as a hindrance toward their access to quality fresh fruits and vegetables. For example, the city of El Paso has a robust public transportation system – Sun Metro. Individuals with no personal vehicles can avail of the Sun Metro public transportation system and do their groceries conveniently. However, the far flung census tracts of the El Paso County – especially areas in the Upper Valley and areas in the Lower Valley (Clint, Socorro, and San Elizario) do not have reliable public transportation systems. Therefore, residents from these areas may experience difficulty in accessing the grocery stores which may result in their having deleterious health condition in the long run.

Non-availability of public transportation systems in these outer fringes of the El Paso County could be addressed by starting shuttle services on the weekend for the residences. The shuttle services can run in the morning hours from certain pick up locations in these census tracts and help the residents commute to the grocery stores where they can do their weekly grocery shopping. This seems to be an ideal and robust approach to address the food desert situation in these areas. The public transportation system in Loudoun County is not very well spread either and the lack of it can hinder people's movement from their place of residence to the grocery stores. Perhaps, a weekend shuttle service can also help such individuals in Loudoun County.

It is also important to mention here that at times canned fruits and vegetables can act as a sound substitute for fresh fruits and vegetables especially for individuals with lack of access to grocery stores. However, the cost associated with this choice needs to be factored in while making the decision making process. In addition, mobility and transportation of senior citizens is always a cause of concern. Due to various medical ailments etc. the senior citizens who live all

by themselves may not be able to access the grocery stores. For such cases, pantry cars with choice of various food options can be a solution.

Finally, the 2015-2020 Dietary Guidelines for Americans has recommended many suggestions that would help individuals make sound eating choices (USHHS and USDA, 2015). It is paramount that for leading a healthy life style, the individual eats nutrient packed food items and exercise on a regular basis. Urban city planners should outline the location of parks and recreational facilities such that people from all strata of the society have access to these at a short walking or driving distance. In addition, individuals should also limit their intake of sugars and calories from high sugared drinks such as soda. In addition, the individual should also reduce his or her intake of sodium.

CHAPTER 8: STRATEGIC FRAMEWORK

This research work on Food Deserts is grounded on various health strategic frameworks that aim to improve the overall health of any community. The following are two frameworks that have played an influential role in understand the Food Desert problem in this region of the U.S.-Mexico border and Loudoun County in Virginia.

8.1 THE SOCIO-ECOLOGICAL MODEL

This thesis work is informed by the important components of the Socio-Ecological Model. The Socio-Ecological model conceptualizes that health behaviors are an outcome of the interactions between individuals and their environment. This environment encompasses several factors and domains – individual factors, interpersonal, organizational, community and policy level factors (Sallis, 2008). The Socio-Ecological Model, as shown in Figure 47, helps toward the understanding of the cultural and social issues facing a given community or sub-group and aids toward the preparation of more effective health promotion strategies.

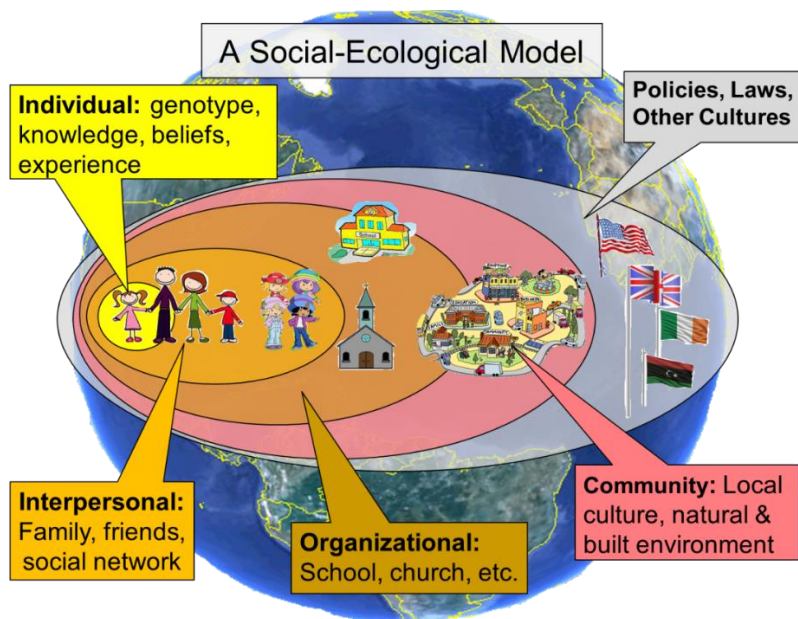


Figure 47: The Socio-Ecological Model

Source: http://sphweb.bumc.bu.edu/otlt/MPH-Modules/PH/PH709_InfectiousAgents/index.html

Public health issues should not be considered in isolation of the cultural, socio-economical and other factors. The Socio-Ecological model is the prevalent general framework in public health understanding of human behavior. Health promotion programs should also be developed in the context of a Socio-Ecological model. The Socio-Ecological model, therefore, is an effective tool or mechanism to address issues pertaining to food deserts in this region of the U.S. - Mexico Border and in the Loudon County, VA.

There are various determinants of health that comprise the various levels of the Socio-Ecological Model. The five levels of the model are individual, interpersonal, organizational, community, and political level. Healthy People 2020 categorizes the determinants of health into various categories (USHSS, 2015) and one of the top 12 outcomes focuses on behavioral health outcomes (Raynor, 2013). These are as follows:

- Biological and Genetics - age, sex, family history of diseases
- Individual Behavior – Diet, nutrition, substance abuse, general hygiene
- Health Services – Availability of medical care, insurance etc.
- Social Factors – poverty, social unrest, racism
- Policy making – laws in sovereign nations and international treaties.

The concept of healthy eating and making judicious decision about one's health, as explained above is influenced by multiple factors – some of which are under the control of the individual in question and some that are not in his or her control but nevertheless have an influence in his or her decision making process when it comes to making healthy eating choices (Sallis and Glanz, 2009). An area devoid of basic services that influence or enhance the quality of life such as recreational parks, healthy eating options such as grocery stores selling fresh fruits and vegetables at not so exorbitant prices are some of the social factors that go a long way in helping

the individual make the said choices. This also throws light on the important topic of policy making decisions both at the local, and the federal level (Sallis et al., 2008). If the concerned authorities adopt policies that would help site grocery stores in low income and minority neighborhoods then most of the health problems afflicting these communities can be addressed and remedial actions can be formulated.

8.2 HEALTHY PEOPLE 2020 INITIATIVES:

This research work is informed by the principles espoused in the Healthy People 2020 framework and guidelines. These initiatives focus on reducing the healthy disparity that may exist along racial or ethnic lines in the United States and aims to forge an environment of health equity (Healthy People, 2020). In addition, these initiatives also aim at reducing many preventable chronic diseases such as obesity, diabetes, and hypertension and in the process improve the overall quality of life for all people regardless of race, socio-economic status, education, or gender.

The following Healthy People 2020 initiatives are directly or indirectly associated with the important topic of Food Deserts in this research work:

- NWS (Nutrition and Weight Status)-3: Increase the number of States in the Union that have State-level policies that incentivize food retailers outlets to provide foods that are encouraged by the Dietary Guidelines of Americans.
- NWS-14: Increase the contribution of fruits to the diets of the population aged 2 years and older.
- NWS-15.1: Increase the contribution of total vegetables to the diets of the population aged 2 years and older.
- NWS-15.2: Increase the contribution of dark green vegetables, red and orange vegetables, and beans and peas to the diets of the population aged 2 years and older.
- NWS-17: Reduce consumption of calories from solid fats and added sugars in the population aged 2 years and older.

The above Nutrition and Weight Status (NWS) objectives of Healthy People 2020 aim at reducing the overall consumption of fat and sugar-dense foods and in turn increase the nutrient-dense foods that are rich in fruits, vegetables, whole grains. Adopting this healthy dietary lifestyle would help offset the deleterious health conditions such as Obesity, Type-2 diabetes, Hypertension, Dyslipidemia, and certain cancers (Healthy People 2020).

CHAPTER 9: MPH CORE COMPETENCIES

The thesis works cover majority of the core competencies of the MPH degree program. The five core courses that form the major bulwark of the MPH program (Environmental Health, Biostatistics, Epidemiology, Social & Behavioral Aspect of Public Health, and Health Services Administration and Health Policy) and the course on Hispanic Health Disparities are the foundations on which this thesis work is built upon.

This research work focuses on the collection of data from federal and state government websites and then employs the usage of Geographic Information Systems (GIS) to address the research questions. GIS technology has revolutionized the way how public health topics are researched.

9.1 BIOSTATISTICS

GIS has numerous inbuilt statistical tests that covered many biostatistics related questions pertaining to this thesis work. Biostatistics in the context of Public Health is the study of statistical reasoning and the implementation of various methodologies to test hypotheses, explore research questions and arrive at sound conclusions. The interpretation of these results help guide the formulation of new policies that would help mitigate the disparities in terms of access to stores selling fresh fruits and vegetables. These policies would then help understand the impact of the formulation of these policies on the overall question of health equity. This research work involved the downloading and cleaning of various socio-economic data from federal government websites such as the US Census Bureau. Calculation of the z-score, regression modeling were also undertaken in this thesis work.

9.2 EPIDEMIOLOGY

In the field of public health, epidemiology is the study of the pattern of diseases in humans, its etiology, and the necessary steps that are undertaken to ameliorate the health complications and diseases. Many research studies have documented that non-availability of fresh fruits and vegetables, especially in minority communities, are the contributing factors responsible for various chronic health conditions such as obesity, diabetes, and certain cancers. Comparing two counties with varying population groups in terms of ethnicity and financial standings under the umbrella of epidemiology helps understand and measure the various health parameters.

9.3 SOCIAL AND BEHAVIORAL SCIENCES

Social and behavioral aspects of public health help define the role of the various cultural, social, and behavioral patterns that play an influential or a contributory role in a population's health. In addition, the various metrics of health disparities that we observe in the American public health landscape today could be attributed to the social and behavioral sciences. In the U.S.-Mexico border region, culture plays a dominant role in the decision making process pertaining to healthy eating habits. Availability of certain foods that form the bulwark of the local cuisine and how the siting of the grocery stores at easily accessible locations was also investigated in this thesis work.

9.4 ENVIRONMENTAL HEALTH

Environmental Health focuses on the various biological, physical, chemical, and anthropogenic factors that contribute to the human health. It also involves the study of identifying these factors and outlaying remedial actions that would minimize their detrimental effects on the human health. Lack of public parks or open spaces, proximity to major industrial

or traffic emission sources such as roadways and highways may have a cumulative effect on a person's health in addition to his or her choices of consuming enough fresh fruits and vegetables. This thesis work, therefore, helped cover this important core competency of the MPH program.

9.5 HISPANIC AND BORDER HEALTH

The comparative assessment of food deserts in El Paso County and Loudoun County helps fulfill the Hispanic and Border Health core competency as well. The social and cultural dynamics in both the counties that result in the existence of food deserts were investigated and propounded upon in this research work. Based on the results obtained from the analyses, this thesis work suggests possible interventions for ameliorating the food desert situation by taking into consideration the acculturation practices of the various ethnic groups in the two counties.

REFERENCES

- American Fact Finder, US Census Bureau (2015):
<https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml> , Accessed on April 06, 2017.
- Atash, F. (1994). Redesigning suburbia for walking and transit: emerging concepts. *Journal of Urban Planning and Development*. 120: 48-57.
- Bovell-Benjamin, A.C., Harthorn, C.S., Ibrahim, S., Gichuhi, P. N., Bronfield, E.M. (2009). Healthy Food Choices and Physical Activity Opportunities in Two Contrasting Alabama Cities. *Health & Place* 15: 429-438.
- Cummins, S., Macintyre, S. (2002). Food Deserts – Evidence and Assumption in Healthy Policy Making. *BMJ* 325, 436-438.
- Cheadle, A., Psaty, B.M., Curry, S., Wagner, E., Diehr, P., Koepsell, T., Kristal, A. (1991). Community-level comparisons between the grocery store environment and individual dietary practices. *Preventive Medicine*. 20(2): 250-61.
- Dalenius, K., Borland, E., Smith, B., Polhamus, B., Grummer-Strawn, L., (2012). Pediatric Nutrition Surveillance: 2010 Report. National Center for Chronic Disease Prevention and Health Promotion, Division of Nutrition, Physical Activity and Obesity, Atlanta.
- Daniels, S.R., (2006). The consequences of childhood overweight and obesity. *Future Child*. 16:47-67.
- Deaton, A., Lubotsky, D. (2003). Mortality, Inequality, and Race in American Cities and States. *Social Science & Medicine* 56, 1139-1153.
- Dubowitz, T., Ghosh-Dastidar, B., Eibner, C., Slaughter, M.E., Fernandes, M., et al., (2012). The Women's Health Initiative: The Food Environment, Neighborhood Socioeconomic Status, Body Mass Index and Blood Pressure. *Obesity (Silver Spring)* 20(4): 862-871.
- Ghosh-Dastidar, B., Cohen, D., Hunter, G., Zenk, S, N., Huang, C., Beckman, R., Dubowitz, T. (2014). Distance to Store, Food Prices, and Obesity in Urban Food Deserts. *American Journal of Preventive Medicine*. 47(5): 587-595.
- Gordon, C., Purciel-Hill, M., Ghai, N, R., Kaufman, L., Graham, R., Van Wye, G., (2011). Measuring food deserts in New York City's Low-Income Neighborhoods. *Health & Place* 17: 696-700.
- Grills, C., Villanueva, S., Subica, A.M., Douglas, J.A., (2014). Communities Creating Healthy Environments: Improving Access to Healthy Foods and Safe Places to Play in Communities of Color. *Preventive Medicine* 69:S117-S119.
- Hallett, L.F., McDermott, D. (2011). Quantifying the extent and cost of Food Deserts in Lawrence, Kansas, USA. *Applied Geography*, 31, 1210-1215.
- Hubley, T.A. (2011). Assessing the proximity of Healthy Food Options and Food Deserts in a rural area in Maine. *Applied Geography*. 31, 1224-1231.
- Keener, D., Goodman, K., Kettel Khan, L., Lowry, A., Zaro, S., (2009). Recommended community strategies and measurements to prevent obesity in the United States:

- Implementation and Measurement Guide, U.S. Department of Health & Human Services, Centers for Disease Control and Prevention, Atlanta.
- Laraia, B.A., Siega-Riz, A.M., Kaufman, J.S., Jones, S.J. (2004). Proximity of supermarkets is positively associated with diet quality index for pregnancy. *Preventive Medicine*. 39: 869-875.
- Loudoun County (2017). Loudoun County Facts. Accessed at <https://www.loudoun.gov/DocumentCenter/View/102862>, on April 22, 2018.
- McKinnon, R.A., Reedy, J., Morrisette, M.A., Lytle, L.A., Yaroch, A.L. (2009). Measures of the Food Environment: A Compilation of the Literature, 1990-2007. *American Journal of Preventive Medicine* 2009, 36(4s): S124-133.
- Morland, K., Wing, S., Diez Roux, A. (2002). The contextual effect of the local food environment on residents' diets: the Atherosclerosis Risk in Communities Study. *American Journal of Public Health*. 92: 1761-1767.
- Paso Del Norte Mapa (2017). <http://www.pdnmapa.org/> Accessed on April 12, 2018.
- Powell, L.M., Auld, M.C., Chaloupka, F.J., O'Malley, P.M., Johnston, L.D. (2007a). Associations between access to food stores and adolescent body mass index. *American Journal of Preventive Medicine*. 33: S301-S307.
- Powell, L.M., Slater, S., Mirtcheva, D., Bao, Y., Chaloupka, F, J. (2007b). Food store availability and neighborhood characteristics in the United States. *Preventive Medicine*. 44: 189-195.
- Pulgaron, E.R. (2013). Childhood Obesity: A Review of Increased Risk for Physical and Psychological Comorbidities. *Clinical Therapeutics*. 35: A18-A32.
- Raynor, P.A. (2013). An Exploration of the Factors Influencing Parental Self-Efficacy for Parents Recovering from Substance Use Disorders Using the Social Ecological Framework. *Journal of Addictions Nursing*. 24(2): 91-99.
- Reisig, V.M., Hobbiss, A. (2000). Food Deserts and how to tackle them: a study of one city's approach. *Health Education Journal*. 59:137-49.
- Sallis, J.F., and Glanz, K. (2009). Physical Activity and Food Environments: Solutions to the Obesity Epidemic. *The Milbank Quarterly*, 87(1): 123-154.
- Sallis, J.F., Owen, N., Fisher, E.B. (2008). Ecological Models of health behavior. In: Glanz K, Rimer BK, Vishwanath K, eds. *Health Behavior and Health Education: Theory, Research and Practice*. 4th ed. San Francisco, CA: Jossey- Bass: 465-482.
- US Census Bureau (2017a): El Paso County Quick Facts. <https://www.census.gov/quickfacts/table/PST045216/48141> Accessed on April 06, 2018.
- United States Census Bureau (2017b). North American Industry Classification System (NAICS). 2017. Accessed at https://www.census.gov/eos/www/naics/2017NAICS/2017_NAICS_Manual.pdf on June 07, 2018.
- US Census Bureau, Tiger Shape Files (2016): <https://www.census.gov/geo/maps-data/data/tiger-line.html> , Accessed on April 06, 2018.

- United States Department of Agriculture (2017): Food Desert Definition. <https://www.ers.usda.gov/data-products/food-access-research-atlas/documentation> Accessed on April 06, 2018.
- United States Department of Agriculture (2009): Access to Affordable and Nutritious Food: Measuring and Understanding Food Deserts and their consequences. A report to Congress, Washington DC: USDA. Accessed at https://www.ers.usda.gov/webdocs/publications/42711/12716_ap036_1_.pdf?v=41055 on April 10, 2018.
- United States Department of Health and Human Services (USHHS). Healthy People 2020- Determinants of Health. <https://www.healthypeople.gov/2020/about/foundation-health-measures/Determinants-of-Health>, Accessed April 12, 2018.
- United States Department of Health and Human Services and U.S. Department of Agriculture (2015). 2015-2020 Dietary Guidelines for Americans. 8th Edition. Accessed at [https://health.gov/dietaryguidelines/2015/resources/2015-2020 Dietary Guidelines.pdf](https://health.gov/dietaryguidelines/2015/resources/2015-2020_Dietary_Guidelines.pdf) on June 19, 2018.
- Walker, R.E., Keane, C. R., Burke, J.G. (2010). Disparities and access to Healthy Food in the United States: A Review of Food Deserts Literature. *Health & Place*, 16: 876-884.
- Zenk, S.N., Schulz, A.J., Israel, B.A., James, S.A., Bao, S., Wilson, M.L. (2005). Neighborhood Racial Composition, Neighborhood Poverty, and the Spatial Accessibility of Supermarkets in Metropolitan Detroit. *American Journal of Public Health*. 95(4): 660-667.

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After pursuing his Ph.D. degree, Amit moved to Atlanta, GA where he pursued a Postdoctoral Research Fellowship at Emory University. His research work investigated the impact of traffic air pollution and its effects on cardiovascular health while commuting on Atlanta roadways. After his Fellowship, Amit moved back to UTEP to pursue a second Master degree in Public Health with a special focus on Hispanic Health Disparities in the Paso del Norte border region.

During his second stint at UTEP, Amit was involved in many research projects. His MPH summer practicum research work focused on the investigation of heavy metals in soils in various neighborhoods of El Paso, TX, and Sunland Park, NM. Amit was also involved with an air quality research project that focused on healthy living guidelines for individuals impacted by traffic emissions near major roadways. During this period Amit was also the recipient of Graduate School Scholarships.

Amit will move to the Rio Grande Valley area of Texas to start a Tenure Track Assistant Professor position in Environmental Sciences (Air Quality) at The University of Texas at Rio Grande Valley, Brownville, in fall 2018.

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