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Factors Related to Access to Nutritious Foods and the Association with Cancer Mortality in the Southeast United States

Krystal Freeman

FACTORS RELATED TO ACCESS TO NUTRITIOUS FOODS AND THE ASSOCIATION WITH CANCER MORTALITY IN THE SOUTHEAST UNITED STATES

By

KRYSTAL NICOLE FREEMAN

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MASTER OF PUBLIC HEALTH

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KRYSTAL NICOLE FREEMAN

Approved:

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Committee Chair

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Committee Member

____
Date

ABSTRACT

KRYSTAL N. FREEMAN

FACTORS RELATED TO ACCESS TO NUTRITIOUS FOODS AND THE ASSOCIATION WITH CANCER MORTALITY IN THE SOUTHEAST UNITED STATES

(Under the direction of Lee Mobley, PhD)

Background: Cancer is one of the leading causes of mortality in the United States. However, nutrient rich diets are known protective factors against this disease. Unfortunately, many areas in the United States do not have adequate access to nutritious foods. This study aims to examine cancer mortality rates in these counties in relationship to access to food. The main hypothesis is that greater accessibility to nutritious food sources in counties is associated with lower county cancer mortality rates.

Methods: Exploratory spatial cluster analysis was used to determine whether patterns of observed cancer mortality were spatially random or not. Finding spatial structure, spatial regression was used to determine the association between several factors related to nutritional access in relation to cancer mortality rates in counties in the Southeastern US.

Results: Results from this study indicated that cancer mortality rates are clustered in the southeast into areas with higher than average and areas with lower than average risk. The patterns are statistically significantly different than would have been observed by chance, using a 5% level of significance. Spatial regression indicated a positive statistically significant relationship between the number of households that live more than one mile away from a grocery store with no vehicle access and increased cancer mortality (p=.00002).

Conclusion: Further research should be conducted to determine which factors in counties are contributing to cancer mortality. Results showed that although individuals have access to healthy foods, they may also have equal access to unhealthy food selections. Behaviors should be assessed to find out what factors influence food choices.

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The author of this thesis is:
Student's Name: Krystal Freeman
Street Address: 1507 Spring Creek Lane
City, State, and Zip Code: Atlanta, GA 30350
The Chair of the committee for this thesis is:
Professor's Name: Lee Mobley, PhD
Department:
College: School of Public Health
Georgia State University
School of Public Health
P.O. Box 3995
Atlanta, Georgia 30302-3995

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CHAPTER I: INTRODUCTION

Cancer is a leading cause of mortality in the United States. The American Cancer Society (ACS) defines cancer as a group of over 100 diseases that arises from uncontrolled cell growth. These cells continue to grow and invade other body tissues. (ACS, 2015). In 2010, it was estimated that cancer cost the United States 124.57 billion dollars. These annual costs are expected to increase to 158 billion dollars by the year 2020 (National Cancer Institute, 2011). Breast and colorectal cancers are the greatest contributors to cancer mortality (ACS, 2013). These types of cancer are associated with dietary factors [United States Department of Agriculture (USDA) & Department of Health and Human Services (HHS), 2011]. There has been an evolution of health reform to include the Patient Accessibility and Affordable Care Act (ACA, 2010), the 2009 Family Smoking Prevention and Control Act (FSPCA, 2009), and continuously revised guidelines for a variety of cancer screening procedures (NIH, 2015). Nutrition and physical activity are known behavioral factors that can significantly impact cancer incidence and mortality (Klein, et al. 2014).

In 2010, HHS issued dietary guidelines in an attempt to combat the rising obesity and chronic disease epidemics. The American Cancer Society (ACS) has also issued nutrition and physical activity guidelines for both cancer prevention and survivorship. These guidelines include increasing fruit and vegetable intake, limiting red and processed meat consumption, and choosing whole grains over refined grains. ACS also encourages increasing access to healthy foods in communities (ACS, 2012). Unfortunately, the Centers for Disease Control and Prevention (CDC) estimate that 33% and 27% of adults consume the daily recommended amounts of fruits and vegetables respectively. Also, nearly 15% of households have been unable to obtain enough food (USDA & HHS, 2011).

Food insecurity negatively impacts diet quality in multiple ways. Independently, lack of food resources can cause stress and trigger the consumption of appetizing, yet unhealthy, foods as a coping mechanism (Leung, et al, 2014). Individuals in food insecure areas also report unhealthy behaviors in general (Tolzman, et al., 2014). The intake of these unhealthy foods contributes to greater BMI and obesity rates in food insecure areas (Holben & Pheley, 2006). Individuals that live in food insecure neighborhoods are also more likely to report hypertension, diabetes and heart disease (Stuff, et al, 2007).

Food insecurity is defined as "*is a household-level economic and social condition of limited or uncertain access to adequate food*" (USDA, 2009). Evidence is mixed regarding food desert characteristics. There is evidence that shows that economically disadvantaged areas are at the highest risk of food insecurity, but studies have also shown that these disadvantaged areas have the same access to nutritious foods as advantaged areas. However, lower income areas have more fast-food and nutrient poor food options than their wealthier counterparts (Alviola, et al 2013).

Although attention to food environment and its role in chronic diseases such as cardiovascular disease and obesity have increased, the association between food environments and cancer has not been thoroughly studied. There are numerous factors relevant to access to food that can also affect cancer mortality including numbers of fast food restaurants, and other comorbid and chronic diseases from poor nutritional health behaviors. This study aims to answer the question, “Is access to nutrition foods associated with cancer mortality?” This study will also assess the question, “Which neighborhood nutritional characteristics are associated with cancer mortality?”

CHAPTER II: LITERATURE REVIEW

A literature search was performed using Georgia State University Library, PubMed, and Google. While conducting this literature search, the following were used as search terms: *food deserts, nutrition and cancer mortality, access to food and health, nutrition and cancer risk, disparities in food deserts, and nutrition and cancer survivorship, nutrition and cancer mortality, nutrition behavior and food choices.* The literature review is arranged in the following format: disparities in food deserts, association between food environment and health, relationship between diet/nutrition and cancer, nutrition behaviors, cancer survivorship and nutrition, cancer mortality and nutrition, and comorbidities and cancer.

Disparities in Food Deserts

Results from a 2012 systematic review determined that low income neighborhoods that have low access to nutritious foods have greater access to fast food sources that promote unhealthful eating. The researchers conducted searches on food environment and neighborhood deprivation to determine if these factors had an effect on fast food consumption and unhealthful eating. These researchers believe that neighborhood design impacts healthy food consumption (Hilmers, et al., 2012).

Low income neighborhoods are also at risk for other factors that can contribute to chronic disease. A 2012 study conducted by Hillier, et al, examined tobacco advertising trends in low income neighborhoods. Results determined that entities that accepted government nutrition assistance were more likely to market tobacco. Tobacco advertising is linked with smoking tendencies. Since smoking is associated with cancer and chronic diseases, low income neighborhoods may be at an increased risk of developing cancer and chronic disease (Hillier, et al, 2015).

In 2014, a cross-sectional telephone survey explored potential differences in food shopping behaviors and the availability of health foods between residents of high and low food access. Although residents of low access food areas reported traveling farther to their primary grocery stores than those of high access food areas, their reporting of healthy food availability and shopping frequency was not statistically different (Sohi, et al., 2014).

In 2014, questionnaires were administered to 2,068 households located in La Crosse, Wisconsin. This area is considered to be a food desert based on the definition determined by the United States Department of Agriculture (USDA). Results from this questionnaire concluded that individuals that live in food deserts were less likely to be able to afford food than individuals that do not live in food deserts. Mean food insecurity was also significantly higher than the national mean, as well as the mean for the state of Wisconsin. Individuals in this area were also more likely to report unhealthy behaviors such as smoking (Tolzman, et al., 2014).

Association between Food Environment and Health

A cross-sectional study performed in 2012 in Detroit, Michigan was conducted to determine if living in a food desert was associated with food consumption, shopping behaviors, and body mass index (BMI). The participants consisted of 1004 individuals recruited in the waiting area of four primary care clinics. These participants were administered a questionnaire that pertained to personal health status, demographics, transportation, and food shopping habits. The results from this survey found that living in a food desert was not associated with BMI (Budynska, et al., 2013).

Bovell-Benjamin, et al. (2009) observed access and availability of nutritious foods and physical activity in grocery stores in two contrasting Alabama cities. One city was considered to be of low socioeconomic status (Tuskegee) while the other was considered to be more affluent (Auburn). In the impoverished Alabama city, none of the convenience stores carried nutritious food options including frozen or low sodium vegetables and low-fat dairy products compared to the 87.5% of stores in Auburn that offer these options. These limited opportunities for nutritious food items could be a contributing factor to chronic disease. The researchers think that socioeconomic status in rural versus urban areas could be associated with access to nutritious foods. However, the researchers feel that these results may not be generalizable to larger areas.

Christian performed research to test for the association between access to grocery stores and coexisting food insecurity and obesity. Data from the Center for Disease Control and Prevention's CDC Behavioral Risk Factor Surveillance System were paired with USDA grocery store access measures. This study determined that as distance to grocery stores increased, the likelihood of obesity for houses in food insecure environments increased as well. This direct relationship shows that access to nutritious foods should be assessed when exploring interventions for obesity and food insecurity (Christian, 2010).

<u>Nutrition Behaviors and Food Choices</u>

Obesity disparities are partially a result of inadequate healthful food access and overwhelming access to low quality foods. Past studies have suggested that a lack of time is an equal contributor to nutritional barriers (Rose, 1999). Low resource households may have little time to shop for and prepare nutritious meals at home resulting from demands such as work, transportation, and child care limitations. A cross-sectional study using data from the American Time Use Survey was conducted to examine associations between social and economic demographics and time spent cooking at home along with eating habits away from home. Results determined only small increases of time spent cooking at home during times of economic hardship. Further studies are needed to define the causes of this lack of change in food behaviors (Smith, et al., 2014).

It is essential to take cultural factors into account when discussing food choices. James conducted six focus groups in a 2004 study to examine the effects of culture on food choices in a selected group of African Americans in Florida. She concluded that the thought of healthy eating was perceived as "giving up a part of their cultural heritage". Other barriers to a healthier diet included cultural symbols of particular foods, increased cost of healthier foods, poor taste, and dearth of nutritional information (James, 2004).

Dimitri and Rogus suggest that creating access to food alone does not promote healthful eating. There are policy mechanisms in place to make food more available, but these policies do not consider behavioral factors. Social demographics, marketing, and behavioral economics must be further evaluated and included in policy formation to actually encourage consumption of nutritious foods (Dimitri & Rogus, 2014).

Nutrition and Cancer Survivorship

Nutrition is an important factor in cancer prevention, but it is equally important in regards to cancer survivorship. A systematic review conducted by the World Cancer Research Fund in 2007 found evidence that identified associations between nutrition, physical activity, and cancer prevention and survivorship. Cancer patients should pay close attention to their nutritious food intake as they are at an increased risk for developing cancer in secondary sites (Witham, 2013).

Another systematic review was designed to introduce the idea of diet as a cancer survivorship intervention. Bazzan, et al. (2013) used previous research to make clinical recommendations to ensure that oncology patients receive enough calories, limit foods that have been linked to modifiable risk factors for cancer prevention, create a diet that minimizes inflammation, and ensure consumption of nutrients linked to cancer prevention. Nutrition is not only essential to physiological health, but for mental and spiritual health as well. Cancer patients often experience weight loss, so adequate calorie consumption is crucial. These calories should come from nutrient rich foods and not foods containing excess sugars and refined carbohydrates. These foods contribute to the onset of other chronic diseases such as diabetes and obesity. These diseases are often comorbidities of cancer. These low nutrient diets also contribute to inflammation, another known pathway of cancer metastasizes and growth (Bazzan, et al., 2013).

A 2010 case study of a patient with breast cancer concluded that nutritional intervention proved to be beneficial to the patient's cancer treatment. The patient had undergone a mastectomy and reported extreme adverse physical and emotion symptoms. Physicians completed a thorough dietary and nutritional assessment and determined that the patient was not meeting basic nutritional requirements for optimum metabolic function. As a result, the physicians customized a nutritional intervention. This improved the patient's energy, metabolic function, and quality of life. These are all important factors in cancer survivorship (Plotnikoff, 2010). A 2011 case control study was also designed to explore health outcomes from nutritional intervention. This study evaluated differences among 537 discharged cancer patients that received nutrition consultation intervention and those patients that did not receive such intervention. Results from this study showed greater positive outcomes in patients that received nutritional consultation (Tu, et al., 2011).

Nutrition and Cancer Mortality

A 2013 systematic review explored the relationship between dietary factors and colorectal cancer mortality. When observing dietary and lifestyle habits in general, results concluded that higher consumption of a Western diet was associated with decreased rate of survival without disease. However, the direct risk of developing colorectal cancer could not be determined from these results. These results did indicate an adverse relationship between meat intake and colorectal cancer mortality. Contrarily, this study found a protective relationship between increased cereal consumption and colorectal cancer mortality (van Meer, et al., 2013).

Diets consisting of high fruit and vegetable intake are linked to decreased breast cancer mortality. This factor of nutrition does not necessarily represent diet quality overall. Using Dietary Approaches to stop hypertension (DASH, 2003) and the Alternative Healthy Eating Index (AHEI, 2010), a diet quality score was identified among breast cancer survivors. There was no association between diet scores and breast cancer mortality. However, adherence to DASH and AHEI diets were associated with reduced risk of mortality from diseases other than breast cancer (Izano, et al. 2013).

Comorbidities and Cancer

There are several diseases that are associated with dietary influences. Giovannucci hypothesized that insulin resistance can increase tumor growth (1995). A 2009 longitudinal study further investigated this relationship using National Health and Nutrition Examination Survey (NHANES) data. Results concluded that insulin resistance contributed to a 41% increase in cancer mortality. Because nutrition is associated with insulin resistance the relationship between nutrition and cancer mortality should be explored (Parekh, et al., 2009).

Dehal, et al. also explored comorbidities of colon cancer using NHANES data. Their study examined death rates at various BMI levels. Results revealed no substantial increases of death rates for all cancers, but BMI was significantly associated with colorectal cancer mortality. Mortality rates were .39, .68, and .96 per 1000 person years for normal weight, overweight, and obese BMIs respectively. The authors suggest further research to identify what factors of obesity contribute to greater cancer mortality risk (Dehal, et al., 2011).

CHAPTER III: METHODS AND PROCEDURES

Methodology and Data

This study focuses on county nutritional characteristics and the relationship with cancer mortality for these counties. The county data were obtained for states in Region 4 of the Department of Health and Human Services (HHS), Public Health Regions (HHS, 2014). The states included Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee.

Data on county cancer mortality by county of residence were obtained from the United States Department of Health and Human Resources Area Health Resource File (AHRF). This database includes data on health resources and socioeconomic indicators at the county geographic level. Cancer mortality was defined using the 3-year malignant neoplasm deaths from the National Center for Health Statistics Mortality Detail Data Files for the years 2008 through 2010. These average annual three year mortality rates were then calculated by taking a sum of the annual death rates from cancer for the years 2008, 2009, and 2010 and dividing this sum by three. Thus, the 3-year rate is an annual average population rate of death from cancer. The county of death was coded as the place of the deceased individual's residence at the time of death.

Demographic and nutritional data were obtained from RTI International's Spatial Impact Factor Database (RTI International, 2012). SIFD data was developed under National Institute of Health (NIH) funding to provide a database for public use that includes a broad set of variables that can describe the environments in which people live (Schad, Mobley & Hamilton, 2011). SIFD is a compilation of data from the United States Census, Health Resources and Services Administration Spatial Data Warehouse (HRSA), Centers for Medicare and Medicaid (CMS), United States Department of Agriculture (USDA), Environmental Protection Agency (EPA), National Cancer Institute's Surveillance Epidemiology and End Results (SEER), and other research institutions.

Conceptual Model of Cancer Mortality Rates in Counties

The variables included in the conceptual model for this cancer mortality rate research include: cancer mortality rates (2008-2010), the percent of uninsured individuals (2000), the number of grocery stores per capita (2007), average distance to closest colonoscopy provider (2006), age-adjusted percentage of adults aged 20 and older that are obese (2007), number of fast food restaurants per capita (2007), percentage of housing units that are more than one mile from a grocery store and do not have access to a car (grocery data is from 2006 and household data is from 2000), and the percentage of the population that is low income and lives more than one mile away from a grocery store (2006 for grocery data and 2000 for household data). The time period for the outcome of cancer mortality of 2008-2010 was used because this was the most recent cancer mortality data in the AHRF. Data for the associated variables was obtained for the years 2000, 2006, and 2007 so that the outcome data occurred after the predictor variables.

The outcome in this conceptual model was cancer mortality rates. The percentage of housing units that are more than one mile from a grocery store with no vehicle and the percentage of the county population that is low-income and lives more than one mile from a grocery store are included to demonstrate access to food. The number of grocery stores per capita was included in the model because literature shows that access to grocery stores can increase access to both nutritious and unhealthy foods (Dimitri & Rogus, 2014). Also, limited access to a grocery store is a characteristic of a food insecure area (Alviola, et al, 2013). The number of fast-food restaurants per capita was analyzed since evidence shows that areas with low access to nutritious foods may have greater numbers of fast food restaurants. Fast food can also contribute to comorbidities of cancer

(Alviola, et al, 2013). Since vehicle access is a factor that can affect access to a grocery store, I hypothesize that this could also affect access to cancer screening. Colonoscopy can prevent cancer and reduce cancer mortality (NCI, 2015). Therefore, I included distance to colonoscopy providers in the conceptual model. BMI and obesity are significant risk factors for cancer outcomes. These comorbidities are also potential outcomes of residing in food impoverished areas (Holben & Pheley, 2006). The age-adjusted percentage for adults with obesity was also included in this analysis.

These data were downloaded into Microsoft Excel 2003 format and converted to DBASE IV format using Stat/Transfer data conversion software (Stat/Transfer, 2015). County geographic shapefiles provided by the US Census Bureau were then linked to these contextual data using the county FIPS code.

Table 1: Selected Variables for Conceptual Model Examining the Association between Food Environment and Cancer Mortality

Variable	Description	Original Data Source	Year
A3_YEAR_MA	Average three year death rate from malignant neoplasms	National Center for Health Statistics (NCHS)	2008-2010
HUNV10	Percentage of housing units in a county that are more than one mile from a supermarket or large grocery store and have no car	Food Environment Atlas Website (USDA)	2006 for store data; 2000 for household data
LOWI1	Percentage of the total population in a county that is low income and lives more than one mile from a supermarket or large grocery store	Food Environment Atlas Website (USDA)	2006 for store data; 2000 for household data
FAST_FOOD_	Number of fast-food restaurants in the county per 1,000 residents	Food Environment Atlas Website (USDA)	2007
PCT_ADULT_	Estimates of age-adjusted percentage of persons age 20 plus with obesity	Food Environment Atlas Website (USDA)	2007
DIST_COL_2	average distance to closest colonoscopy provider for ZIP codes in this unit	Centers for Medicare and Medicaid (CMS)	2006
GROC_PC0	Number of supermarkets and grocery stores in the county per 1,000 residents	Food Environment Atlas Website (USDA)	2007

Data Analysis

GeoDa software for spatial data analysis (GeoDa, 2014)) was used to perform descriptive exploratory data analysis, and spatial regression analysis. Spatial clustering analysis using the Local Indicators of Spatial Association or LISA test (Anselin, 1995) was conducted first. Finding evidence of significant local spatial clustering, spatial regression was then used to determine relationships between the cancer mortality rates, nutritional and demographic factors accounting for the influence of neighboring county values for 726 counties in the Southeast United States.

LISA is a spatial clustering statistic that indicates the extent of spatial clustering around a specific observation. This takes the average neighborhood cancer mortality rate, and identifies areas where there are patterns of similarities that are not expected by chance. These clusters are discovered by comparing the rates of six counties in the sample 999 times to determine a correlation. If the correlation is statistically significant ($p<.05$), then there is evidence of a pattern that is not by chance. Spatial weights were constructed to enable conducting the LISA cluster analysis and spatial regression. The 6 closest neighbor weights were used in the analysis, which identifies a county's neighbors as the six closest counties around it to calculate the Moran's I coefficient (Anselin, 1995).

LISA indicates the presence of significant spatial clusters. Results depict spatial similarities among neighboring areas. Maps generated by LISA identify local clusters of areas of above average cancer mortality surrounded by counties of similar cancer mortality, as well as areas of below average cancer mortality surrounded by areas that also have below average cancer mortality (Anselin, 1995).

Next, an ordinary least squares regression was run, using these weights, to determine whether there were spatial effects in the regression data that needed to be modeled. Specification tests described in Mobley et al (2006) were used to determine whether a spatial lag or a spatial error specification was more appropriate. There was strong spatial autocorrelation, as indicated in the exploratory LISA tests, and the spatial lag model was the best specification based on the regression diagnostics in GeoDa.

Coefficients and the respective p-values from the spatial regression were used to determine positive or negative relationships between variables and their statistical significance. This spatial lag model was used to account for the extent to which variables in one area are influenced by variables in neighboring areas, so that regression estimates and significance tests could be unbiased. Results from both ordinary regression and spatial lag regression are included to show the differences in the results when spatial effects are accounted for.

Hypotheses to be Tested in the Spatial Regression Modeling

The conceptual model, based on the literature review, describes the covariates to include in the model. Based on the literature, there are several hypothesized relationships that can be defined for the model. These hypotheses describe what the direction (sign) of association is to be expected between the covariate and the outcome. Results from the literature determined that nutritious foods are associated with reduced cancer mortality, and that consumption of unhealthy foods is associated with greater cancer mortality. Other chronic diseases such as diabetes and obesity are also associated with an increase in cancer mortality. This led to the formation of the following hypotheses

- The percentage of housing units in a county that have low access to food is positively associated with cancer mortality.
- The percentage of a county population that has low access to food is positively associated with cancer mortality.
- The number of supermarkets and grocery stores per capita is negatively associated with cancer mortality.
- The number of fast-food restaurants in a county per capita is positively associated with cancer mortality.
- The percentage of adults with obesity in a county is positively associated with cancer mortality.
- The average distance to a colonoscopy provider is positively associated with cancer mortality.

CHAPTER IV: RESULTS

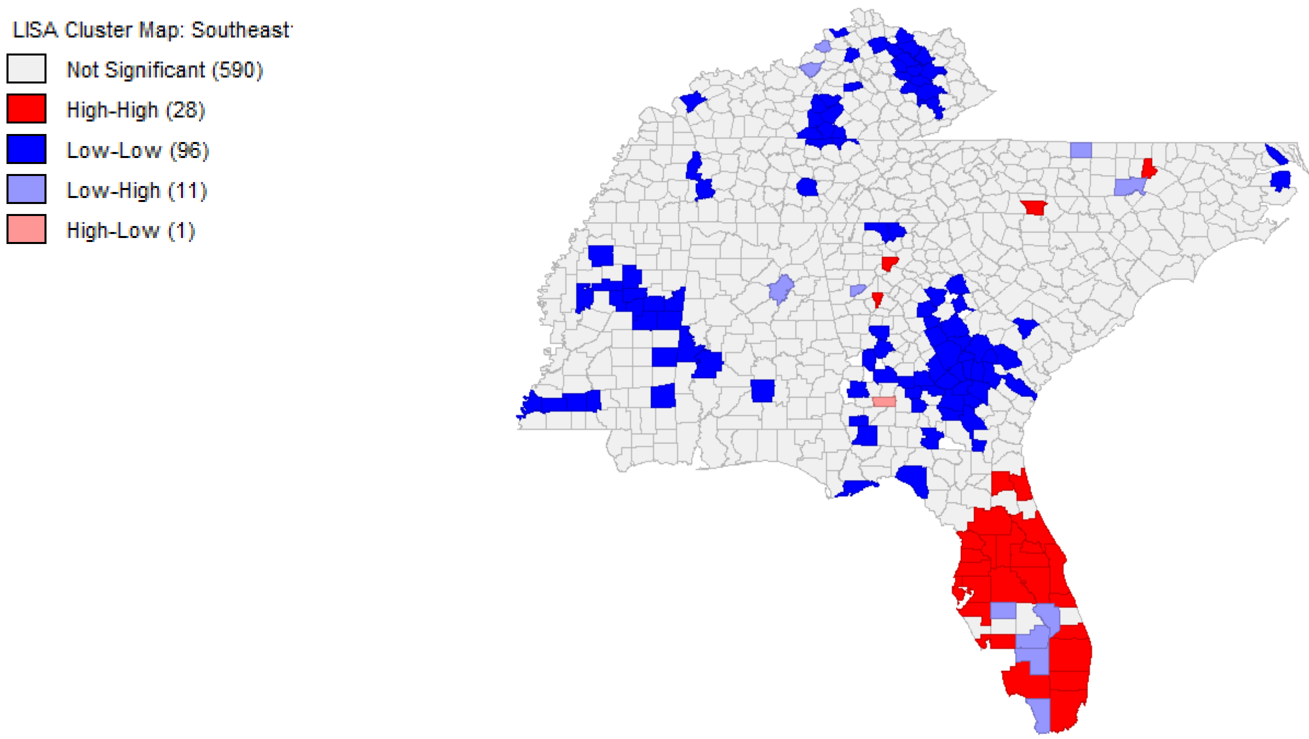
Data was available for 736 counties in the Southeast United States. LISA results are presented first, followed by the spatial regression results.

LISA Exploratory Analysis

LISA analysis depicts clusters of statistically significant spatial associates to account for possible similarities in practices of neighboring counties. Blue areas represent counties with below average cancer mortality rates that neighbor counties that also have below average cancer mortality rates. Red areas depict counties of above average cancer mortality that are surrounded by counties that, too, have above average cancer mortality rates. Pale red and pale blue areas depict counties with cancer mortality rates that differ from the rates of its neighboring counties (Anselin, et al., 2006).

Results from the exploratory, descriptive LISA analysis of the county mortality rates identified six areas where clusters of counties with similar mortality rates are located. Clusters of below average cancer mortality rates (blue) are located in central Mississippi, western Alabama, southeast Georgia, eastern Kentucky, and central Kentucky. The statistically significant county clusters of below average cancer mortality during 2008-2010 in the Southeast are depicted in Figure 1. The clusters properly include the county identified in the colored section of the map, and its six closest neighbors (Schieb et al, 2013). Florida contains a large cluster of counties with above average cancer mortality rates (red). These counties are also depicted in Figure 1. There is also a cluster of high cancer mortality located in the metropolitan area of Atlanta, Georgia.

Figure 1: Results from LISA Spatial Clustering Analysis of Average Annual County Cancer Mortality Rates during 2008-2010: Spatial Clusters of Above-Average County Rates (red) and Below Average County Rates (Blue) in the Southeast United States



Regression Results

Table 2: Results from Ordinary Least Squares and Spatial Lag Regressions

	Ordinary Least Squares Regression (OLS)		**Spatial Lag Regression**	
Variable	**Coefficient**	**p-Value**	**Coefficient**	**p-Value**
A3_YEAR_MA*			0.539	0.0000
HUNV10	30.43	0.00002	26.11	0.00002
LOWI1	-16.42	0.0000	-12.28	0.0000
FAST_FOOD_	-46.49	0.34256	45.99	0.31042
PCT_ADULT_	-23.36	0.0000	-13.21	0.00006
DIST_COL_2	-7.84	0.00043	-7.39	0.00012
GROC_PC0	174.38	0.09684	172.02	0.05788
*This variable represents the spatial lag coefficient				

Ordinary least squares model is conducted first to determine whether the existing spatial dependence is spatial lag or spatial error. With spatial lag, observed outcomes are determined simultaneously with neighboring outcomes. In spatial error, factors in neighboring are unobserved (Mobley et al, 2006). Lagrange Multiplier results from the ordinary least squares regression are used to determine spatial dependence. Since the lag Lagrange Multiplier was more significant in these results, lag spatial dependence was used (Mobley, et al, 2006).

Results from spatial lag regression in Table 2 indicate statistically significant relationships at the .05 level between cancer mortality rates and number of housing units with no vehicle that are more than one mile from a grocery store (p=.00002), percentage of low-income individuals that live more than one mile away from a grocery store (p=.0000), the percentage of obese adults (p=.00006), and the average distance to the nearest colonoscopy provider (p=.00012). The lag parameter, cancer mortality rate, is also statistically significant (p=.0000). A significant lag parameter is important as it demonstrates spatial dependence. This means that the parameters in the ordinary least squares regression are overestimated (Mobley, et al, 2006). This means that the values of cancer mortality observed in a county location are influenced by values of its surrounding neighbors (Anselin, et al., 2006).

The percentage of housing units that are located more than one mile away from a grocery store with no access to a vehicle (HUNV10) was positively associated with cancer mortality and statistically significant. This met the expectations of the hypothesis. The percentage of the county population that was low income and lived more than one mile from a grocery store (LOWI1) was negatively associated with cancer mortality and was statistically significant. This rejected the initial hypothesis. As the number of fast food restaurants per capita (FAST_FOOD_) decreased, cancer mortality increased. These data also rejected the initial hypothesis. Obesity (PCT_ADULT_) was inversely associated with cancer mortality and statistically significant. These results did not meet the expectations of the initial hypothesis based on the literature. The number of grocery stores per capita (GROC_PC0) was positively associated with cancer mortality; however, these results were only slightly significant (p=.05788). This rejected the initial hypothesis.

CHAPTER V: DISCUSSION AND CONCLUSION

Clusters of High Cancer Mortality Rates

The statistically significant spatial clusters found by the LISA analysis can be explained by numerous factors. The clusters of low cancer mortality are located in rural areas. These areas may have lower access to cancer screenings (Horner-Johnson, et al, 2014). Poor people and rural dwellers who are not screened may have died from cancer, while this was not known or reported. Few cases of cancer mortality are discovered from autopsy, because autopsy is not routine. So there may be an urban-rural and SES bias in the cancer mortality data that are reported.

There are other factors in these rural areas that could explain why cancer mortality rates are lower in these areas. These areas may have decreased access to fast food and other unhealthy food options that may contribute to cancer and cancer mortality. The Florida clusters could have a slightly different explanation. Florida is known for its population of older individuals who migrated there at retirement age from other regions of the US. The risk of chronic disease increases with age. Therefore, Florida's above-average clusters of cancer mortality rates could be due to the older population demographics of the residents. The cluster of high cancer mortality rates in the Atlanta, Georgia area may be influenced by a large number of medical centers, thus increased cancer screening opportunities. Atlanta is also a very urban city with greater access to unhealthy food options.

Associations between Factors included in the regression model and the county cancer mortality outcome are discussed next. These findings are not always as expected under the hypotheses posed above.

Results from the spatial lag regression show a statistically significant (p=.00002) positive association between the percentage of housing units in a county that have low access to healthy foods and no vehicle (HUNV10) and cancer mortality. However, the percentage of the overall county population that had low access to food (LOWI1) was not significantly associated with increased cancer mortality. The reason for these results may be tied to vehicle access. Although low-income individuals may not live near a grocery store (LOWI1), this population may have vehicle access that allows them to reach areas of fast food or other unhealthful food resources. These results agree with the results of Sharkey, et al (2010).

Greater numbers of grocery stores per capita (GROC_PC0) was also associated with increased cancer mortality. However, this variable had a weaker statistically significant positive association with increased cancer mortality (P=0.05788). This means that although individuals living in areas with accessible grocery stores had greater access to nutritious foods, they also had access to junk food and may not have made nutritious choices.

There were a number of variables that were associated with decreased cancer mortality. These results were not expected based on the hypotheses. As the number of fast food restaurants per capita decreased (FAST_FOOD_), cancer mortality increased. However, this result was not statistically significant (p=.31042). The same results were concluded with the distance to the nearest colonoscopy provider (DIST_COL2). As neighborhoods become farther from colonoscopy screening facilities, cancer mortality decreases. This may be due to a lack of urbanization in these areas (Berrigan, et al, 2014). Rural areas may not be exposed to some cancer causing agents including pollution and easy access to fast-foods.

Limitations & Future Implications

A major limitation to this study is that it does not take into account the behaviors of the residents. Although healthy food is available, consuming it may not be the preference of county residents (Dimitri & Rogus, 2014). A future study to examine the behaviors and choices of residents in these areas would be very beneficial to determining how access to food affects cancer mortality. Another limitation to this study is mortality rate itself. The majority of studies in the literature examined cancer incidence rather than mortality. Since individuals may relocate after their cancer diagnosis to facilitate treatment, the location at time of diagnosis may not be accurately recorded. It is necessary to capture where the cancer diagnosis was made to determine if nutrition access made an impact. Relocation of cancer patients causes confounding because it modifies the county where the patients' deaths occur. Death rates in counties with cancer centers may be higher due to this relocation. Therefore, data for these counties can be misleading (Tu, et al, 2012). Also, mortality rates to not provide information on an individual's complete physical history. Death certificates are not always complete and the true cause of death may not be captured if a person has multiple contributing factors that led to their death (Van Der Velden, et al, 2009).

This study is limited by its cross-sectional design. Cross sectional studies can only assess one specific point in time and cannot determine causality. Therefore, this study can only generate hypotheses (Bland, 2001). Literature shows that nutrition can influence cancer mortality (Izano, et al. 2013); however, poor access to nutrition is not the only cause of cancer mortality. ACS has determined that one third of cancer deaths are attributed to diet and physical activity. This mortality data does not distinguish cancer death attributed to other causes such as genetics, chemical exposures, tobacco use, etc. This study does not distinguish cancer mortality by cancer site. Since not all cancer types are associated with nutrition, this study is limited. A future study may explore cancer mortality by cancer site. Other studies have examined numerous lifestyle factors that contribute to cancer and mortality (van Meer, et al., 2013). Smoking behaviors, physical activity, chemical exposure, and other behavioral determinants should be assessed. Including these variables in future studies may be a more effective approach for determining what locational factors affect cancer mortality.

Age, race, and gender are demographic factors that should be considered when exploring health outcomes. This study did not incorporate demographic factors. Since demographic variables were only available for the year 2000, they were not included in this study. Without accounting for demographics, the study cannot entirely determine which factors are contributing the most to cancer mortality in food insecure neighborhoods. As future data is available, these aspects should be explored.

Although the results from the LISA analysis suggest that age might play a role in cancer mortality, this data was not included in the conceptual model. The most recent data available for county age is from the year 2000. Future studies may be able to incorporate current age data into a similar model.

Conclusion

It is well known that healthy, nutrient rich diets can be protective against several forms of cancer. This study found a significant association between living in areas of low access to nutritious foods and increased cancer mortality. However, this study also found a weakly positive association between the numbers of grocery stores per capita and increased cancer mortality. The literature review noted that although healthy foods may be available, there are numerous factors including culture, food choices, taste preferences, and other behavioral factors that determine what foods are being consumed (James, 2004). Future studies will be needed to determine which behavioral and lifestyle factors are contributing to food choices. Results from the literature found that increasing access to foods (i.e., grocery stores) does also increase access to unhealthy foods. It does not change food preferences or behaviors. Policies designed to create more availability for food must consider behaviors in order to the healthfulness of dietary intake (Dimitri & Rogus, 2014). Research is very limited in the association between cancer mortality and access to nutritious foods. More research is needed to explore which specific built environment factors affect cancer mortality. Access to food should be enhanced for food insecure neighborhoods. This could include neighborhood gardens, farmers markets, etc.

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Donna B Johnson (djohn@uw.edu) Emilee Quinn (equinn1@uw.edu) Marilyn Sitaker (sitakerm@battelle.org) Alice Ammerman (alice_ammerman@unc.edu) Carmen Byker (carmen.byker@montana.edu) Wesley Dean (wesley.dean@fns.usda.gov) Sheila Fleischhacker (sheila.fleischhacker@nih.gov) Jane Kolodinsky (jkolodin@uvm.edu) Courtney Pinard (cpinard@centerfornutrition.org) Stephanie B Pitts (jilcotts@ecu.edu) Joseph Sharkey (jrsharkey@srph.tamhsc.edu). Developing an agenda for research about policies to improve access to healthy foods in rural communities: A concept mapping study. *BMC Public Health*. 2014;2(14):592. http://ezproxy.gsu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=97115074&site=eds-live.

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