NORTHERN ILLINOIS UNIVERSITY

Geography of Obesity and Related Health and Socioeconomic Factors in Chicago, Illinois

A Capstone Submitted to the

University Honors Program

In Partial Fulfillment of the

Requirements of the Baccalaureate Degree

With Honors

Department Of

Geographic and Atmospheric Sciences

By

Peyton Whiston

DeKalb, Illinois

May 11, 2019
Capstone Title (print or type)

Geography of Obesity and Related Health and Socioeconomic Factors in Chicago, Illinois

Student Name (print or type) Peyton Whiston

Faculty Supervisor (print or type) James L. Wilson

Faculty Approval Signature James L. Wilson

Department of (print or type) Geographic and Atmospheric Sciences

Date of Approval (print or type) May 5, 2019

Check if any of the following apply, and please tell us where and how it was published:

☐ Capstone has been published (Journal/Outlet):

☐ Capstone has been submitted for publication (Journal/Outlet):

☐ Capstone has been presented (Conference):

☐ Capstone has been submitted for presentation (Conference):

Completed Honors Capstone projects may be used for student reference purposes, both electronically and in the Honors Capstone Library (CLB 110).

If you would like to opt out and not have this student’s completed capstone used for reference purposes, please initial here: _______ (Faculty Supervisor)
HONORS CAPSTONE ABSTRACT

Guidelines

Your abstract should begin with a definitive statement of the problem of project. Its purpose, scope and limit should be clearly delineated. Then, as concisely as possible, describe research methods and design, major findings, including the significance of the work, if appropriate, and conclusions.

Students whose thesis involves “creative” work (original, fine art, music, writing, theatre or film production, dance, etc.) should describe process and production. Indicating the forms of documentation on file as “thesis” materials.

Please have your advisor review your abstract for organization, content, grammar and spelling before submission.

Obesity is a major global health concern, but few studies have examined the spatial distribution of obesity and related health factors on a neighborhood level scale. In this project, our study area is Chicago, the third largest city in the United States and a very diverse metropolitan area. For this project, Microsoft Excel, SPSS, and MGWR software was used for statistical analyses while QGIS was used for mapping purposes. Significant correlations were found among all of the health metrics that were analyzed. There was also a strong correlation between the hardship index, a composite of various socioeconomic factors, and obesity rates. Mapping these variables revealed a clustering of poor health and poor socioeconomic status on large parts of the south and west sides of Chicago. These findings suggest that policies to improve the health of Chicagoans must specifically target these neighborhoods with a variety of strategies that focus on the variety of determinant of obesity and its related health issues.
The Geographic Relationship Between Obesity, Poverty, and Other Health Variables in Chicago, Illinois

1. Background

Obesity has relatively recently become a major global health issue both in the United States and around the world. Worldwide, the number of obese adults has tripled since 1975 to 1.9 billion. Defined as an adult Body Mass Index (BMI) of 30.0 or greater, obesity can further be subdivided into three classes: class I (BMI 30.0-34.9), class II (BMI 35.0-39.9), and class III (BMI 40.0 and up). After decades of rapid increase in the United States, obesity prevalence is now showing signs of leveling off (Ogden et al., 2016). As of 2013-2014, the age-adjusted prevalence of obesity was 35.0% among men and 40.4% among women (Flegal et al., 2016). Previous research has shown correlations between the consumption of sugar-sweetened beverages and the presence of obesity and other related health problems such as type 2 diabetes and cardiovascular disease (Malik et al., 2010). On a national level, there are disparities when it comes to obesity rates when it comes to race, with Asian-Americans having lower rates of obesity than African Americans, Hispanics, and non-Hispanic Whites (Skinner et al., 2016). In terms of income, Americans living in counties with the highest rates of poverty are also the most prone to obesity (Levine, 2011).

Recently, some cities have introduced targeted sweetened beverage taxes in an effort to discourage the consumption of these beverages and offset the health costs that they cause. The first city to implement this was Berkeley, California in November of 2014. Following the implementation of the tax, sales of sugar-sweetened beverages declined, while overall consumer spending remained the same, suggesting that this may be an effective way to reduce consumption of sugar-sweetened beverages (Silver et al., 2017). In Cook County, Illinois, a one cent per ounce
soda tax went in to effect in August of 2017, before being repealed less than four months later. In Chicago, adults living below the poverty line are more than twice as likely to have consumed sweetened drinks on a daily basis compared to those living on an income greater than four times the poverty line. African-American Chicagoans are more than three times as likely to have consumed a sweetened beverage on a daily basis compared to non-Hispanic Whites. Some areas on Chicago’s south and west sides persistently have low access to healthy food, commonly referred to as food deserts. This situation has worsened recently in some areas after the closure of grocery stores during The Great Recession. These food deserts are disproportionately found in areas of lower income, higher unemployment, and higher minority populations (Kolak et al., 2018).

One previous study on whether one’s neighborhood environment directly contributes to health conditions such as diabetes and obesity focused on women with children living in public housing. Women who were given vouchers that allowed them to move to a low-poverty census tract had modestly lower obesity rates and glycated hemoglobin levels compared to women who remained in public housing in high poverty urban census areas (Ludwig et al., 2011). This suggests not just a correlation, but a causative link between the neighborhood you live in and health outcomes. Other studies have investigated a correlation between the use of food stamps through the Supplemental Nutritional Assistant Program (SNAP) and high obesity rates. The magnitude of the observed effect has varied among the various studies. These observations have led researchers to question how the program could be improved to reduce its obesogenic effects (DeBono et al., 2012).

There is a plethora of factors outside of what is considered here that can influence obesity rates in a neighborhood. For example, as may be expected, adolescents living in more walkable
neighborhoods obtained more physical activity and more frequently used walking as their method of transportation. This remained true throughout different metropolitan areas and through neighborhoods or varying income levels (Sallis et al., 2018). A similar study in Utah used multilevel modeling to combine individual socioeconomic attributes with neighborhood environment factors to examine risk factors for obesity at multiple spatial scales. At the ZIP code level, poverty rate and distance to parks were significant covariates of obesity while the presence of fast food restaurants was a significant factor at the county level (Xu et al., 2015). A study from Europe examined the geographic variation of obesity but focused on a country-level scale. Among the factors they investigated was physical activity measures, such as the promotion of cycling within the country, but also physiological and genetic differences among the countries. They state that there is conflicting evidence on some of these factors such as the frequency of meals. Some studies indicate that a low meal frequency is better while other evidence indicates that snacking leads to obesity (Blundell et al., 2017). Finally, one very recent study from Chicago, investigated the influence of psychosocial stressors on the odds of becoming obese. Using data from the Chicago Community Adult Health Study, the researchers found that factors like childhood adversities, financial strain, or relationship stressors are all associated with increased odds of obesity. Of the many potential factors that can influence the risk of a person becoming obese, we will look at a few of these in this study.

2. Data

We hypothesize that obesity will be significantly correlated with other health factors by analyzing community area level data. It is also expected that there will be correlations between obesity and socioeconomic community area level measures. We will map these variables, along
with coefficient of variation and the residual values for the data to possibly reveal spatial trends in the data.

Chicago is divided into 77 community areas that have changed little since the original 75 community areas were designated in the 1920s by sociologists at the University of Chicago. This makes them ideal for comparisons over space and time. A base map of the 77 community areas of Chicago was obtained from the City of Chicago data portal online. Healthy Chicago 2.0 was a four-year long community health assessment completed by the Chicago Department for Public Health and the Partnership for Healthy Chicago. Through this assessment, data on a variety of factors related to mortality, morbidity, socioeconomic factors, and health behaviors are freely available, broken down by community area.

The relationship of adult obesity to adult physical inactivity, adult soda consumption, diabetes deaths, heart disease deaths, and hypertension was studied. Adult obesity was defined as the estimated percent of adults 18 years and older who have a body mass index (BMI) of 30 or greater. Adult Diabetes was defined as the percent of adults aged 18 and over who had been diagnosed with diabetes by a health professional. Adult physical inactivity was defined as the percent of adults 18 years and older who reported not participating in any physical activities or exercises in the past month. Adult soda consumption was defined as the percent of adults 18 years and older who drank any sweetened beverage at least once per day over the past month. Hypertension was defined as the percent of adults 18 years and older who had been diagnosed with high blood pressure by a health professional. Heart disease was defined as the percent of adults who had been diagnosed by any kind of heart condition, including a heart attack, angina, congestive heart failure, or coronary artery disease.
All health data was obtained from the Chicago Health Atlas, part of the larger Healthy Chicago 2.0 plan. The data included 95% confidence intervals which was used to determine the variation within the data. All health data obtained was for the years 2015-2017.

Furthermore, the City of Chicago has created a “hardship index” for each of these 77 community areas. This index is based on six socioeconomic indicators of public health significance: the percent of occupied housing units with more than one person per room, the percent of households living below the federal poverty level, the percent of persons in the labor force over the age of 16 years that are unemployed, the percent of persons over the age of 25 years without a high school diploma, the percent of the population that is under 18 or over 64 years of age, and per capita income. This hardship index data was obtained from the Chicago Data Portal and was based on data from the years 2008-2012. Other socioeconomic data from the Chicago Data Portal was used as well.

3. Methods

Chloropleth maps were created for six different variables: adult diabetes, adult obesity, adult physical inactivity, adult soda consumption, heart disease, and hypertension. (MAPS 1-6). The coefficient of variation was also mapped for each of these six different variables. (MAPS 7-12) This maps uncertainty based the data from the Healthy Chicago 2.0 survey.

Using SPSS software, Pearson’s correlations were calculated among these six variables as well. (Table 1). Using the general linear model, it is possible to determine the residual values based on the predicted value from the model subtracted from the observed value. The residual value tells us how much higher or lower the value is from what is expected. In order to map the residuals, first a univariate general linear model was conducted in SPSS. In the general linear model, the adult obesity rate was the dependent variable. Then each of the five other variables
were input as covariates one by one. We also ran a multivariate linear model comprised of the five independent variables, although this led to more null values because if there was missing data in any of the five categories, then the residual would not be calculated for that community area. The residuals were saved in the SPSS data sheet. This data sheet was saved as a CSV file that was able to be imported into QGIS. Then, in QGIS, the residual values were refactored and joined to the shapefile of community outlines. From this, it was possible to create the maps of the residual values based on the multivariate linear model (Map 13).

The MGWR program was downloaded from the website of the Spatial Analysis Research Center at Arizona State University. This program can conduct multiscale geographically weighted regressions (MGWR) to explore geographically varying relationships between independent and dependent variables while taking into account the local relationships between these predictors. First, the centroid point for each community area was calculated in QGIS. Then, this was exported as latitude and longitude coordinates that could be imported into the MGWR software as the x and y spatial values. MGWR analyses were calculated for the relationship between adult obesity and the five other health related variables (Table 4).

The other part of this project focused on the relationship between obesity and the socioeconomic condition of each community area, as measured through the hardship index and other socioeconomic variables. Three measures of socioeconomic status were correlated with adult obesity using Pearson’s correlations: percent of households below the poverty line, percent of adults unemployed, and per capita income (Table 2).

4. Results

Based on the community level data, significant positive correlations exist between the five health measures included and prevalence of adult obesity (Table 1). Four selected indicators of
neighborhood socioeconomic conditions were also correlated with prevalence of adult obesity (Table 2). A positive correlation exists between the adult unemployment rate, percent of households below the poverty line, and a neighborhood hardship index with prevalence of adult obesity. A negative correlation exists between per capita income and prevalence of adult obesity. A linear regression model with adult obesity as the dependent variable and the five health measures as predictors resulted in an $R^2$ value of 0.681 (Table 3). This shows that a large amount of variation in the rates of adult obesity rates can be explained by these health factors. $R^2$ values for the MGWR are lower than the Pearson Correlation values, but still show significant correlation, even after taking into account the geographic variation among the parameters.

As expected, visual analysis of the chloropleth maps produced indicate community areas that are lagging behind in these measures of the health of people in the community. The maps of the coefficient of variation do not show a clear trend as to certain areas of the city that have consistently high levels of variation in the data. Finally, the map of the residual values of the model incorporating all five health factors does not show a clear spatial clustering in the city (Map 13). There are both positive and negative residual values on all sides of Chicago indicating that there is not a part of Chicago where the obesity levels are consistently higher or lower than what would be expected. With this model, if there were missing data for any of the five values, the model would not calculate for that community area. So, in map 13, any community area shaded in black represents a null value.

When looking at these maps of the residual values, areas with negative values suggest that the obesity levels are lower than what would be expected given the prevalence of these health
factors in the community area. Areas with positive residual values have higher than expected obesity levels based on the prevalence of these health factors.

5. Discussion

Moving forward, these results may suggest areas of Chicago that should be specifically targeted through future public health initiatives in order to improve the health of these neighborhoods. While the focus of this project was on adult health factors, interventions should be started at a young age in order to reduce the chance of these issues developing in individuals in the first place. This could include healthy eating initiatives in school cafeterias or programs such as Safe Routes to School that encourage walking and biking to school primarily through infrastructure improvements. Programs such as these have existed for decades in order to encourage children to maintain a healthy lifestyle. It’s important to note that while programs focusing on a healthy lifestyle in schools have been proven to be effective, programs that emphasize weight loss could be harmful to adolescents. Officials in Chicago and all cities throughout the country should ensure that funding for programs such as these are being equitably distributed to all neighborhoods.

There is now a fairly large body of research that suggests that one’s neighborhood environment is associated with obesity. In Chicago, life expectancy at birth can vary up to 17 years depending on the neighborhood that you live in. Organizations like the Healthy Communities Foundation and the Center for Community Health Equity, a collaboration between DePaul University and Rush University, are working to diminish these health disparities in Chicago as well as the suburbs.

Future research should continue on this topic. Particularly, focus should be on children’s health and their neighborhood environment. In other cities, studies have examined the changes in
obesity and related health and socioeconomic factors over time. A similar study could be conducted in Chicago, as there is data for multiple years available through the Healthy Chicago 2.0 study. Other factors such as sex, race, income level, or educational level could be more fully incorporated into these future studies.

6. Reflection

Personally, this capstone project has allowed me to expand my knowledge of a variety of geographic software and various ways to apply statistical analysis to geographic problems. Previously, I have used the QGIS software for the GEOG 256 course here at NIU but conducting an independent study project like this was much more challenging and interesting than any of my previous experience with QGIS. In my future career as a physician, I would like to actively consider the various geographical and socioeconomic factors that may be influencing a person’s health. This project has also been a great way to finish my experience as part of the University Honors Program here at NIU.

7. References


8. Maps and Figures

Table 1: Pearson Correlation Values among Obesity and other Health Measures

<table>
<thead>
<tr>
<th></th>
<th>Soda Consumption</th>
<th>Physical Inactivity</th>
<th>Diabetes</th>
<th>Heart Disease Deaths</th>
<th>Hypertension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation Value</td>
<td>.612</td>
<td>.603</td>
<td>.506</td>
<td>.530</td>
<td>.501</td>
</tr>
<tr>
<td>Significance Value (2-Tailed)</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
</tbody>
</table>
### Table 2: Pearson Correlation Values between Obesity and Socioeconomic Conditions

<table>
<thead>
<tr>
<th></th>
<th>Hardship Index</th>
<th>Adult Unemployment Rate</th>
<th>Per Capita Income</th>
<th>Percent of Households Below the Poverty Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation Value</td>
<td>.624</td>
<td>.614</td>
<td>-.666</td>
<td>.411</td>
</tr>
<tr>
<td>Significance Value (2-Tailed)</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
</tbody>
</table>

### Table 3: Linear Regression Model with Adult Obesity as the Dependent Variable

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
<th>R Square Change</th>
<th>F Change</th>
<th>df1</th>
<th>df2</th>
<th>Sig. F Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.825a</td>
<td>.681</td>
<td>.651</td>
<td>6.3593722</td>
<td>.681</td>
<td>22.655</td>
<td>5</td>
<td>53</td>
<td>.000</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), Hypertension_Percent, Inactivity_Percent, Diabetes_Percent, Heart_Disease_Percent, Adult_Soda_Percent

### Table 4: MGWR R Squared Values among Obesity and other Health Measures

<table>
<thead>
<tr>
<th></th>
<th>Soda Consumption</th>
<th>Physical Inactivity</th>
<th>Diabetes</th>
<th>Heart Disease Deaths</th>
<th>Hypertension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Obesity</td>
<td>.375</td>
<td>.380</td>
<td>.319</td>
<td>.281</td>
<td>.251</td>
</tr>
</tbody>
</table>
Map 1:

Adult Obesity Rates in Chicago, Illinois

Percentage of Obese Adults by Community Area

- 0.0000 - 20.6600
- 20.6600 - 29.8200
- 29.8200 - 35.4800
- 35.4800 - 42.6600
- 42.6600 - 59.5000
Prevalence of Adult Diabetes in Chicago, Illinois

Legend
Percentage of Adults Diagnosed with Diabetes By a Health Professional
- 0.0 - 5.6
- 5.6 - 11.2
- 11.2 - 16.8
- 16.8 - 22.4
- 22.4 - 28.0
Map 3:

Adult Physical Inactivity in Chicago, Illinois

Percentage of Adults Who Reported Not Exercising In the Past Month

- 0.0 - 18.6
- 18.6 - 25.1
- 25.1 - 28.6
- 28.6 - 33.7
- 33.7 - 47.0
Map 4:

**Adult Consumption of Sugar-Sweetened Beverages in Chicago, Illinois**

Percentage of Adults Consuming Sugar-Sweetened Beverages Daily

- 0 - 18
- 18 - 24
- 24 - 31
- 31 - 41
- 41 - 60

Legend: 0 - 2.5 km, 2.5 - 5 km, 5 - 7.5 km, 7.5 - 10 km
Map 5:

Death from Heart Disease in Chicago, Illinois

Legend
Age-Adjusted Rate of Heart Disease Deaths

- 105 - 158
- 158 - 211
- 211 - 264
- 264 - 316
- 316 - 369

2.5 0 2.5 5 7.5 10 km
Map 6:

Prevalence of Hypertension in Chicago, Illinois

Percentage of Adults Diagnosed With Hypertension
- 0.0 - 20.1
- 20.1 - 26.5
- 26.5 - 30.8
- 30.8 - 38.1
- 38.1 - 57.7
Map 7:

Coefficient of Variation for Adult Obesity Rates

Legend

Coefficient of Variation
- 0.00 - 0.00
- 0.00 - 0.71
- 0.71 - 1.02
- 1.02 - 1.39
- 1.39 - 1.91

5 0 5 10 15 20 km
Map 8:

Coefficient of Variation for Adult Diabetes Rates

[Map with color-coded regions indicating the coefficient of variation for adult diabetes rates]
Map 9:

Coefficient of Variation for Physical Inactivity Rates

Coefficient of Variation

- 0.00 - 0.36
- 0.36 - 0.71
- 0.71 - 1.07
- 1.07 - 1.42
- 1.42 - 1.78
Map 10:

Coefficient of Variation for Adult Soda Consumption
Map 11:

Coefficient of Variation for Heart Disease Deaths

Coefficient of Variation
- 0.122 - 0.226
- 0.226 - 0.329
- 0.329 - 0.432
- 0.432 - 0.536
- 0.536 - 0.639
Map 12:

Coefficient of Variation for Adult Hypertension Rates
Map 13:

Residual Values for Obesity Based on All Five Health Measures