Assessing Neighborhood Health using GIS:
Looking Beyond the Socioeconomic Status

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Abstract

We know that where a person lives has an impact on the person's health, but how much do we know about the criteria for assessing the health of a neighborhood? Socioeconomic status (SES), derived from census data, is an important factor in measuring the health status of neighborhoods. It is the contention of this paper that for a more accurate measurement, SES should be considered in context with other criteria.

Where neighborhood health is concerned, communication among health researchers, communities, urban planners, and policy experts is necessary. With the largest elderly population in the country, Florida faces specific challenges for neighborhood health. This paper is a starting point for identifying neighborhood factors contributing to the health quality of a neighborhood. Further study is needed to evaluate the importance of these neighborhood factors.

Assessing the health of neighborhoods can help professionals better target educational programs and allocate resources that could improve health care and reduce costs. This paper proposes the development of a weighted multi-attribute index to be used in conjunction with Geographic Information Systems (GIS), a proven visualization and analysis tool. Analysis using this GIS data can be used to assess a variety of factors determining neighborhood health and inform the development of public health solutions that can more accurately identify specific areas of concern.

Introduction

The connection between health and housing has been well known for over a century. Florence Nightingale once wrote, "The connection between health and the dwelling of the population is one of the most important that exists" (Hood, 2005). We know that where a person lives has an impact on the person's health, but how much do we know about the criteria for assessing the health of a neighborhood? Socioeconomic status (SES), derived from census data, is an important factor in determining the health status of neighborhoods, and it is the contention of this paper that a more accurate measurement should consider SES in context with other criteria.

This paper examines numerous factors that should be used in context with other criteria when measuring the health of neighborhoods. Expanding factors beyond SES will provide a more complete picture of the health of the area. These resulting factors can be used to create a weighted index to quantify neighborhood health according to selected attributes and their estimated contribution to health. The resulting index can be used in a Geographic Information System (GIS) to help analysts target areas directly regarding their area of specific interests. Furthermore, having well-rounded, contextual information will enable health care professionals to better target education campaigns and allocate resources that could result in improved health care and reduced costs.

The research question for this review is: what neighborhood attributes (other than socioeconomic status) could be related neighborhood health? The purpose of this article is two-fold: to provide a discussion of attributes mentioned in the literature as possible contributors to neighborhood health; and to suggest the use of a weighted indexing technique in conjunction with a GIS to assess a variety of factors in measuring neighborhood health.

Background

Why Study Neighborhoods?

Physicians have long considered the context of individuals and their families as related to health habits and decisions. Many habits and decisions regarding our health are influenced by the environment around us, specifically with neighborhood locations. With GIS technology and increased access to data, it is now possible to study the context of where people live and what short- and long-term affects it may have on an individual.

Ultimately, GIS allows visualization and analysis of data from multiple resources across space. Chronic disease prevention plays an important role in our health care system, and health professionals should use these available technologies to better understand health habits. It is possible to envision an electronic health record that provides information on location, such as nearby places for exercise or healthy food, social services, walkability measures, and other health lifestyle data. Physicians could use this information for recommendations to the patient regarding their own specific habits and decisions regarding their health. Additionally, specific areas can be targeted for interventions (Berke, 2010).

The interest in studying the relationship between neighborhoods and public health is closely linked to several current and interrelated trends. First, there is the sense that individual-based health explanations are insufficient on their own and that neighborhoods provide a broader context because of the physical and social attributes affecting individual health. Second, there is interest in understanding the social inequalities of health. Third, is the idea that epidemiology should be better understood in a context of policies (especially those not considered to be health-related but could have a health impact). Fourth, there are popular methods available to study neighborhood health effects (e.g. multi-level analysis, GIS, and spatial analysis) that allow examination of space in a more detailed manner than in the past (Diez-Roux, 2007).

Limitations of Socioeconomic Status (SES)

Socioeconomic factors are often used in geographic studies for various reasons. The SES data is collected and distributed by the United States Bureau of the Census, which makes it easily obtainable, affordable, relatively current, consistent across diverse areas (e.g. rural and urban), and it can be consistently quantified every year. Census data has a long history of use with information specialists as well as researchers and the use of SES data throughout many studies that has been proven effective. A study conducted between socioeconomic status and cardiac arrest showed that low socioeconomic status is associated with poor cardiovascular health (Reinier, 2011). Furthermore, another study analyzing high risk of stroke and myocardial infarction in the Appalachian area used a composite measure of SES: race, gender, age, income,

education, poverty, housing value, geography (urban vs. rural), employment, single parent status, and housing ownership. After adjusting for other factors, the study concluded that findings were consistent with SES and chronic disease (diabetes and hypertension) expectations (Pedigo, 2011). Both of these studies show great consistency in how using SES could be effective in research and assessing health. Overlooking poverty and inequity interfere with our understanding of disease etiology and distribution and to do so would, first, wrongly obscure the devastating impact of poverty on population health, and, second, undercut our commitment to scientific rigor (Kreiger, 2007).

Failure to consider socioeconomic implications has produced biased epidemiologic knowledge that has harmed the public's health. People are both biologic organisms and social beings, and we cannot study one without the other (Krieger, 2007). Residing in deprived areas can increase the risk of mortality beyond what can be explained by a person's socioeconomic factors and lifestyle. Past research has shown that participants in the highest quintile of neighborhood deprivation had elevated risks for overall mortality and moderate increases in cancer and cardiovascular-related deaths. When taking education into consideration, education levels had little significance (Doubeni, 2011). But, when taking neighborhood residence and mental health outcomes into consideration, there is a major significance. Based upon experimental evidence, not only did boys who moved from high-poverty public house to near-poor neighborhoods have significantly fewer anxious depressive and dependency problems than did boys who stayed in public housing, but also parents who moved to low-poverty neighborhoods reported significantly less distress than parents who remained in high-poverty neighborhoods (Leventhal, 2003).

There are factors affecting health and neighborhoods that SES cannot address. A survey of community gardens identified characteristics that may be useful to facilitate neighborhood development and health promotion. Results revealed that low-income areas were four times as likely as non-low-income areas to lead to addressing of other neighborhood issues (presumably based on the organization achieved in making the garden) (Armstrong, 2000). Other studies have shown that adjustments for socioeconomic values cannot fully explain the health findings. The results suggest that other factors warrant consideration, such as access to health care services, quality schools, recreational facilities, stores, healthy food. Neighborhood-based attitudes towards health-related behaviors, such as smoking, physical activity, diet, and the degree of social support should be also considered (Pedigo, 2011). Although neighborhood problems are higher in low SES areas, problems are more associated with poor self-related health, psychological stress, and impaired physical function rather than associated with smoking, diet, alcohol, or physical activity. Neighborhood problems are independent of age, sex, and neighborhood SES. These findings suggest that chronic stress can increase poor health (Steptoe, 2001).

Although there are many benefits in using SES in public health studies, problems also do arise. Using SES as a control variable and less frequently as the variable of main interest can affect findings and conclusions. Examples from past research show racial/ethnic differences in income and wealth at different educational levels and raise concerns about the comparability of individuals on education or income alone (Braveman, 2005). There has been a discussion of causal mechanisms behind health measures and socioeconomic status, but few natural experiments to identify causal paths. A study testing for the absence of direct causal links from

SES to and from health conditions and wealth was performed on elderly United States individuals where Medicare and Medicaid programs can limit patient's out-of-pocket expenses and the ability to work was not a factor. The study found no causal link of SES to mortality, except through sudden diseases. The results were mixed for chronic and generative disease. Overall, the hypothesis for direct cause from health conditions to wealth change was rejected (Adams, 2004). SES can be considered a start to understanding neighborhood health that can be enhanced by taking other factors into consideration. Improvements to the use of SES could be made by more thoughtful use of existing information and by acknowledging the limitations through considering existing points, such as different socioeconomic measures cannot be assumed to be interchangeable, standard measures may not reflect relevant and important aspects of SES, racial/ethnic differences are likely to reflect unmeasured socioeconomic differences, and a given SES measure may have different meanings in different social groups (Braveman, 2005).

Advantages of Using a Multiple-Attribute Weighted Index

Given the shortcomings of the SES, there is a need to consider other factors that could play a role in assessing neighborhood health. A multiple-attribute weighted index could include selected information from the SES plus additional information from other selected sources. This custom index would not only allow modelers to include and focus on factors they consider important, but would also further aid them in research directly regarding the modelers' ideas based on data or personal opinions. Dulin et al. (2010) used a multiple attribute weighted index to determine areas in Charlotte, North Carolina that could benefit from additional primary care. The resulting Multi-attribute Primary Care Targeting Strategy (MAPCATS) index uses attributes decided upon by a community advisory board consisting of representatives of local hospitals, clinics, and universities. The five key attributes used were socioeconomic status, population density, insurance status, patterns of ED utilization, and primary care safety-net. The strengths of the MAPCATS index is that input and feedback are received from local professionals, the data is easily collected, the attributes are easily weighted according to available data and opinions, and the model is relatively easy to create. Follow-up studies are planned to evaluate the method on an individual basis (Dulin, 2010). This paper suggests creating a multi-attribute weighted index similar to MAPCATS for the purpose of assessing neighborhood health. This paper also contains a list of possible input attributes that could be chosen and weighted at the local level by those interested in assessing neighborhood health.

Advantages of Using Geographic Information System (GIS)

GIS in its modern form has been used to visualize and analyze disease data, particularly to identify disease clusters. Every individual lives and interacts with their environments, both manmade and natural. GIS can give a spatial component to non-spatial data such as claims records, poverty, and environmental pollutants. GIS can integrate contextual factors of a person's environment with health characteristics (Berke, 2010). GIS and spatial analysis techniques can allow exploration of neighborhoods in a more detailed and thoughtful manner than has been available in the past (Diez-Roux, 2007). The earliest and most famous use of GIS dates to the 1854 cholera outbreak in London's SoHo district. The outbreak killed 127 people in three days. Anesthesiologist John Snow mapped the deaths and noticed a clustering around a

well. Even though cholera was thought to be an airborne disease, Snow removed the handle of the Broad Street well, thus containing the outbreak. Snow's pencil-and-paper discovery led to increased sanitation efforts and healthy neighborhood habits (Robbins & Klotz, 2013).

Methodology

The methodology for this study is a review of research literature to identify and document a broad range of attributes that could be factors in assessing neighborhood health. Articles were searched by a variety of terms such as "assess neighborhood health", "neighborhood health", and "GIS and neighborhoods". Originally the search was limited to medical journals, but the results produced duplicate articles on popular topics such as access to health care and nutritious foods. This strategy did not produce the broad range of topics that was the original intent of this paper. The search was expanded to be of a multi-disciplinary nature and include literature from urban planning, sustainability, and public policy as these fields offered additional insights of relationships between neighborhoods and health. The articles are categorized according to the attribute defined in the article in an attempt to create an orderly list of factors.

Results

Medical Factors

Patterns of Emergency Department Utilization

The New York University (NYU) Center for health and Public Research has created an algorithm to classify the appropriateness of emergency department visits. The NYU emergency department algorithm identified the following categories: 1) Non-emergent (medical care was not required within 12 hours); 2) Emergent/Primary Care Treatable; 3) Emergent with emergency department care needed but preventable or avoidable with access to primary care; 4) Emergent with emergency department care needed and not otherwise preventable (NYU). A study funded by The Commonwealth Fund reviewed 6 million emergency department visits from 1998 and found that New York City's uninsured populations use emergency department for medical care, in spite of attempts to improve primary care access. An examination of emergency department use among zip codes revealed differences in use across neighborhoods. A follow-up survey of Bronx emergency department users showed that 60% of those surveyed had been ill for more than 3 days, 16% for more than a week, and 9% for more than a month (Billings, 2000). Ultimately, the algorithm used to classify appropriateness of emergency department visits could assist in using these results as evidence of extending the information towards a multi-attribute weighted index and for further assessment of a broader population.

Health Records

Health records and health information exchanges are an important part of information infrastructure. However, past health records based on "encounter" information provide information on the individual and are not as useful for assessment of the broad population. As future research and technology develop, electronic health records may still have the possibility of providing beneficial information towards GIS and a multi-attribute weighted index towards

assessment of neighborhoods and also assist in clinical decision support. Inaccuracies in paper documentation and poor interdisciplinary communication resulted in numerous medical errors. Data can be retrieved from an electronic health records system to examine patient populations, manage chronic disease, and ensure preventive care applications in ways that paper documentation was unable to do (Thurston, 2014). The future of electronic health records could assist GIS in exemplifying multiple neighborhood factors outside of SES. Public health information systems, including immunization registries, can provide information about geographic areas. According to Hinman (2010), immunization information systems led the way in linking population-based data and health care delivery. They have a longer history and are more mature than most other public health information systems. They are the best public health database suited for clinical decision support. The future of developing electronic health records combined with current immunization information systems can assist in a variety of medical factors and allow future advancements with the use of GIS and a weighted index.

Neighborhood Accessibility and Deprivation Factors

Access to Quality Food

Neighborhood location and access to quality food account for a majority of individuals eating habits. There is a large body of literature on "food deserts" contributed by many disciplines. Studies show that residents with more access to supermarkets and less access to convenience stores have better diets. Residents having limited access to fast food have healthier diets and lower levels of obesity. Studies involving access to restaurants are less consistent with their findings. Residents of low-income, minority, and rural neighborhoods often have poor access to healthy foods and supermarkets. Lower-income and minority neighborhoods have a greater prevalence of fast-food restaurants and energy-dense foods (Larson, 2009). Travel distances to fast-food were shorter in more deprived neighborhoods while travel times to fast-food restaurants were twice as far in the least socially deprived neighborhoods. Similar patterns were found for stores selling healthy foods such as supermarkets (Pearce, 2007). Individual-level data verified that a significant number of food pantry clients in Pomona California in 2003 had limited access to fresh produce, with almost half of the clients having no access to fresh produce at all. Identifying concentrations of food pantry clients is important because mobile food trucks could be used to distribute fresh foods (Algert, 2006). Results from past studies on neighborhood accessibility and access to quality food allow future research to relate these types of external factors among broader populations.

Densities of Liquor and Tobacco Access

Deprived neighborhoods have more liquor stores than lesser-deprived neighborhoods, even though the higher SES neighborhoods are more likely self-report to be heavier drinkers. It is unclear if lower SES neighborhoods accurately report the role of alcohol and it is possible that high SES feel more freedom to report alcohol usage, possibly explaining the perceived correlation between alcohol use and SES. Higher concentrations of convenience stores are significantly associated with higher levels of individual smoking, regardless of how the measurement of the convenience stores is calculated (Hood, 2005).

Environmental Concern Factors

Toxic Releases & Air Pollution

Different health outcomes (e.g. birth defects and cancer) can be tracked through extensive research over a certain period of time, and results come from well-developed registries. But, registry systems are nonexistent or not fully developed when it comes to cases regarding autism, diabetes, or Alzheimer's. Registries are not always the most practical way to track all diseases. Therefore, The California Policy Research Center has made recommendations for an environmental health surveillance system to be used as a tool for preventing chronic diseases that are related to the environment. The report identifies a need to track air pollution, pesticides, water pollution, hazardous waste, solid waste, radiation, exposure to metals, persistent organic pollutants, indoor hazards (tobacco smoke, radon, mold), asbestos and volatile organic compound (University of California, 2004). Toxic releases and air pollution go hand-in-hand when dealing with health outcomes. A study in Italy found that respiratory health status can be affected by residing close to traffic-related air pollution. Subjects living within 100 meters of a major road showed increased lung function impairment including persistent wheezing, Chronic Obstructive Pulmonary Disease (COPD) diagnosis, asthma diagnosis, and dyspnea (Nuvolone, 2011). While originally the use of hazard-tracking systems were to describe environmental quality and document regulatory compliance, it could advance into helping collect information about chemicals used and population exposure, which is a major limitation occurring in existing systems (University of California, 2004). GIS could help in the development of an exposure map regarding these factors.

Lead Exposure & Housing Construction

Lead exposure is far more common in the United States than what one might expect. It is still a public threat in our environment today. A study in Chicago examined the associations between demographic risk factors and housing characteristics to determine pediatric lead exposure. Two neighborhoods with high concentrations of minority populations had the highest prevalence. The findings showed significant association with living in pre-1950s housing (Oyana, 2007). An Atlanta study showed a significant association between lead exposure and participation in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) program and an insignificant relationship with older housing (Vaidyanathan, 2009). Current news stories of toxic home construction materials (e.g. flooring and drywall) as a source of lead contamination show that lead exposure expands to new construction and home improvements with unclear ties to SES. Using GIS in combination with a neighborhood spatial approach would provide improved geographic areas to assign and assess risk factors in lead exposure. Once an exposure map has been developed, the researchers work with local health departments to selectively and proactively screen children for lead exposure, and to educate new parents who live in high-risk housing about how to prevent their children from being exposed (Hood, 2005).

Aesthetic Factors

Walkability & Physical Activity

Walkability has many health and environmental benefits. Walkable neighborhoods show significant decrease in blood pressure for middle-aged and older adults. Neighborhoods with low walkability and high density of fast-food outlets were significantly associated with increased blood pressure over time. Neighborhoods with high walkability combined with a high fast-food outlet density showed diminished negative effects for residents who met physical activity guidelines and eating fresh fruits and vegetables (Li, 2009). Many individuals are prone to more walking when they are in close proximity to parks. Park size is not a significant predictor of physical activity while parks with features, such as trails or wooded areas, are more likely to be used for physical exercise. Other amenities such as restrooms, bicycle racks, attractive landscaping are likely to attract users for activity purposes. These findings suggest that park planning can affect physical activity (Kaczynski, 1998). Walkability can be quantified by a walking index, which scores an area's ability to support walkability and physical activity. There are many algorithms for calculating a walkability score, and many are based on the ability to walk to destinations such as grocery stores, schools, parks, restaurants, and retail outlets. Increased walkability has shown great relevance towards health promotion and decreases the risks of excess weight. Approximately doubling the proportion of neighborhood residents walking to work decreases an individual's risk of obesity by almost 10%. Older neighborhoods can have an advantage as adding a decade to the average age of neighborhood housing decreases women's risk of obesity by about 8% and men's by 13% (Smith et al. 2008). A ten-percent increase in the walkability score is associated with nine more minutes per week of walking (Hirsch et al. 2013). The walkability index shows significant features of health promotion and being used in parallel with GIS would allow planners to view the walkable areas.

Housing Program Participation Factors

Section 8 Tenant-based Assistance Program (The Housing Choice Voucher Program)

Housing is an important factor regarding mobility and neighborhood health. The Section 8 Program is administered by state and local housing agencies under contract to the federal government. The Section 8 program supplements housing payments for low-income families and individuals in the private housing market. (This differs from public housing programs, which subsidizes housing projects for the poor.) Tenant-based assistance allows recipients to choose moderately priced housing in the location that best suits their needs, with participants typically paying 30% of their incomes toward housing and the Section 8 program contributing the remainder.

Tenant-based housing is increasing in numbers compared to the traditional project-based housing programs (Turner, 2000). Although, there have been concerns that clusters of Section 8 households can destabilize neighborhoods by attracting drugs, crime, and antisocial behavior. These ideas are linked efforts to use the Section 8 program for poverty de-concentration. Currently, there is no evidence indicating that Section 8 is undermining the health of neighborhoods in spite of significant levels of geographic clustering. Nevertheless, the potential for neighborhood impacts should not be ignored. Policymakers should work to

strengthen the program to help recipients while avoiding excessive clustering in vulnerable neighborhoods. Programmatic changes such as assembling and maintaining information about amenities, services, and transportation, simplifying portability practices, hands-on assistance with housing search, and "second move" counseling could all help strengthen the program (Turner, 2000).

A study of neighborhood housing interventions or policies researched the following ten interventions linking neighborhood-level housing to health outcomes: rental vouchers, relocation to low-poverty neighborhoods, demolition of distressed public housing, universal design, environmental design, growth and connectivity design, residential siting away from highways, zoning, density bonuses, and green space around housing. Of these ten interventions, there is sufficient evidence to show that the Section 8 program was the only intervention that warranted expansion. The voucher program was able to mitigate negative health outcomes due to food insecurity for children. The data suggest that housing subsidies could protect the nutritional status of children in food-insecure households (Lindberg, 2010). With further research, there could be more detailed implications for the other interventions to link neighborhood-level housing interventions to health outcomes. With the addition of further research, it would a significant impact when mapping housing in GIS and involving neighborhood-level housing interventions through a weighted index.

Subjective Measured Factors

There is a substantial difference among individuals when regarding self-reported health and observed/assessed health. While researching neighborhood socioeconomic environment and self-reported poor health, it was found that in some cases self-reported poor health is associated with neighborhood SES measures and individual educational attainments (Malmström, 1999). Nevertheless, self-reported and secondary accessibility characteristics are important factors in neighborhood health. Perceived neighborhood quality has a significant effect after adjusting for neighborhood SES and individual socioeconomic factors. These findings suggest that reliance on census-based neighborhood measures is insufficient in assessing the full neighborhood picture (Wen, 2006).

Studies assessing the availability of healthy food often rely upon quantitative measures such as counting the number of supermarkets within a geographic area such as a census tract. This type of assessment does not necessarily take into account the quality of the food available. A study comparing GIS-based densities with the availability of healthy foods in several geographic areas as reported by those in the neighborhood shows positive associations that are not very strong (Moore, 2008). A study on diabetes measured neighborhood perceptions of crime, trash, litter, night lighting, and access to transportation, supermarkets, and exercise facilities. Adjustments were made for socioeconomic status and neighborhood clustering of diabetic patients. Results show that residents reporting the most perceived neighborhood problems had the higher smoking rates, higher blood pressure, and less weekly physical activity (Gary, 2008). Reflecting on both of these studies, future research should take into account quality of food available, as well as neighborhood perception so that future researchers may apply it to a specified multi-attribute weighted index and apply GIS toward neighborhood problems so future researchers could conduct an in-depth analysis towards a broader population.

Demonstration

This demonstration uses the weighted multivariate index to provide a preliminary assessment of physical activity in disadvantaged areas in Leon County, Florida. Lack of sufficient physical activity poses a health concern for all neighborhoods. Disadvantaged areas could be particularly affected by lack of physical activity as this may compound existing socioeconomic concerns. Health researchers of at-risk areas may be interested in identifying locations needing special attention such as educational outreach programs on the importance of physical activity. This study uses SES data to identify disadvantaged areas, then considers non-SES data to potentially offer preliminary insight into general physical activity of a neighborhood.

The study area consists of three 2010 census block groups with the lowest education and highest rates of public assistance in Leon County, as shown in Figure 1.

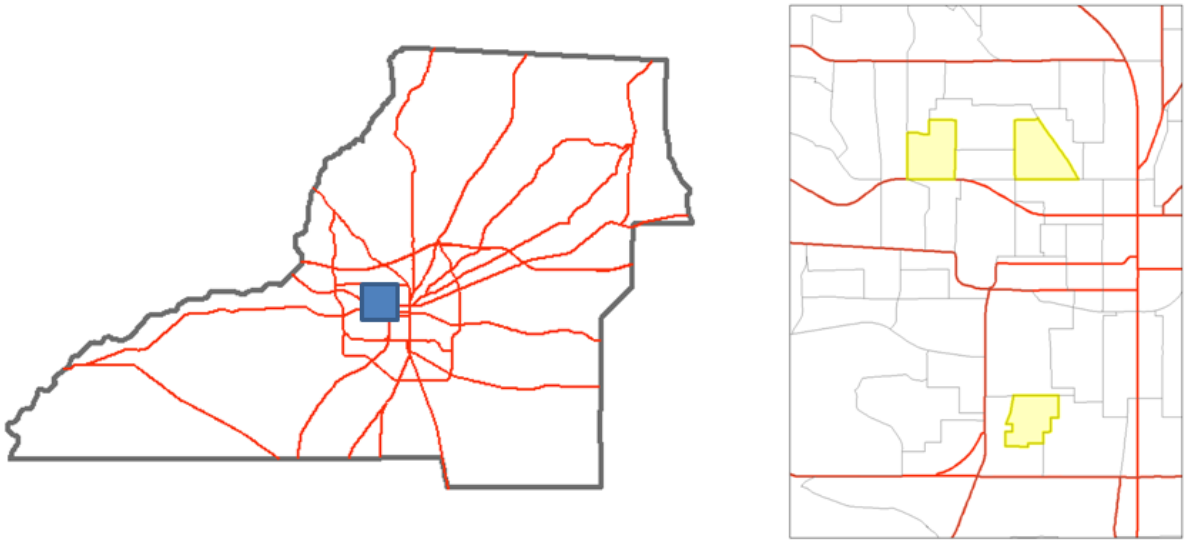

Figure 1. Overview of Leon County with study area highlighted (a); close-up of study area (b) with disadvantaged block groups highlighted.

Three types of supplemental data have potential to assess possible physical activity in the areas. The first type of data is proximity to public parks. Convenient, no-cost access to greenspaces provides the opportunity for outdoor exercise. The second type of data is a walkability score that shows the ability to perform errands on foot from a residence as measured on a scale from 0 to 100. A higher walkability score gives potential for exercise through daily activities. Figure 2 visualizes the walkability of Leon County using a formula (Frank et al, 2009) with readily available data such as population, land use mix, retail density, and transportation nodes, but does not consider other factors such as sidewalk condition, safety, or other localized data.

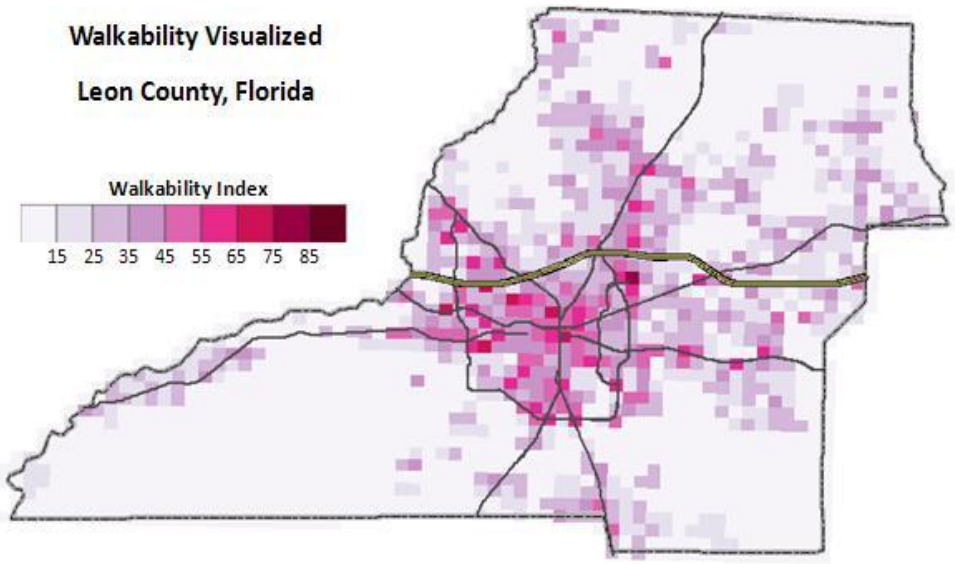

Figure 2. A visualization of walkability index of Leon County.

The third type of information selected for this study is addresses where Florida fresh-water fishing licenses have been issued. Fishing licenses can show interest in the outdoors that assumes a minimal level of physical activity. Figure 3 shows the licenses issued for Leon County.

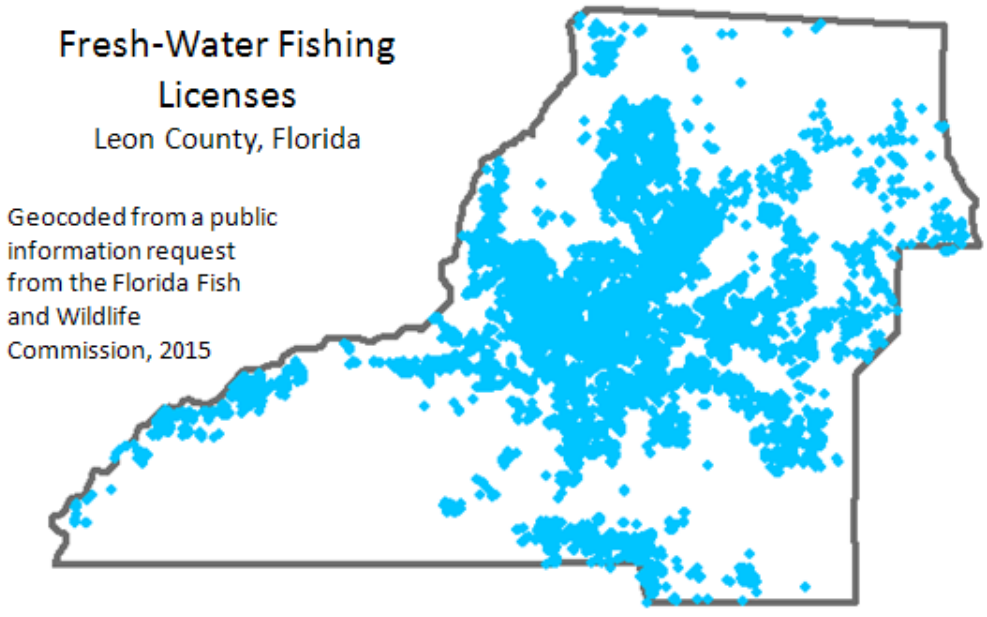

Figure 3. A visualization of fresh-water fishing licenses.

Visual overlays show the spatial relationships of the data. The study area has parks both within and bordering the neighborhoods. Figure 4 shows that the walkability scores of the study area and proximity are relative high, making them some of the most walkable areas in the county (as determined by the formula). Figure 5 shows the fishing licenses in and near the study area.

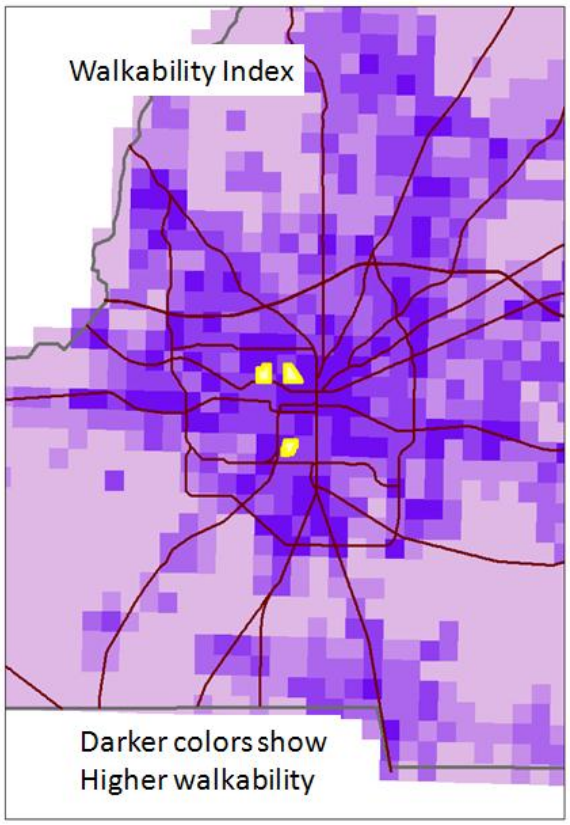

Figure 4. A close-up of the study area in relation to overall walkability in the county.

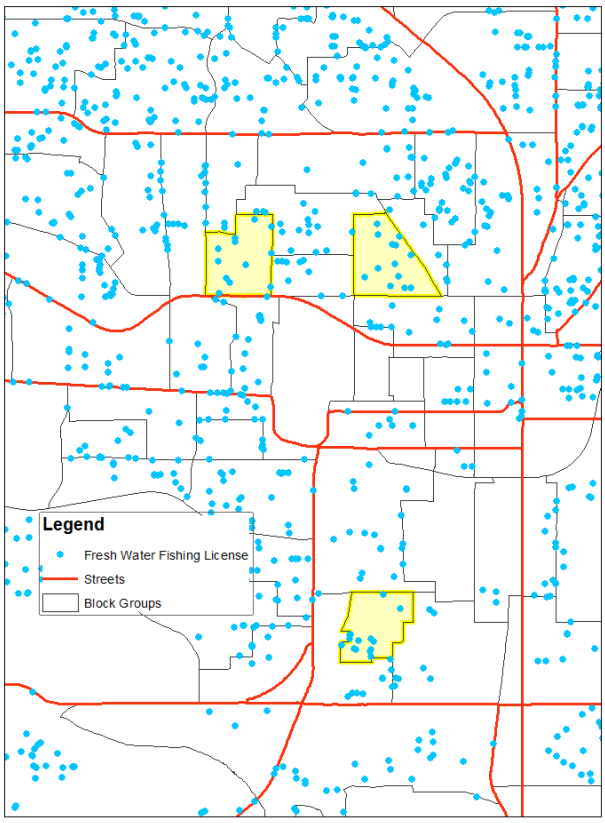

Figure 5. Fresh water fishing licenses in and around the study area.

The fresh-water fishing license rate is lower in the study area than the county average of 4%. However, fishing can be a considered sport in more affluent neighborhoods but a source of food supplementation in less affluent areas, and licensure could correlate with SES data. For this study, the rate of fishing license holdings is compared with neighboring block groups to avoid comparisons with affluent areas. The study area has an average .011 licensure rate, but neighboring block groups have percentages ranging from .004 to .009. These numbers show that the study area rates range from slightly higher to double the license holdings as proximate block groups, even though neighboring block groups are not considered as disadvantaged according to SES data.

Of the three types of supplemental data considered here, two show opportunity for exercise and one shows interest in an outdoor activity. Figure 6 overlays the supplemental data layers for an overall perspective.

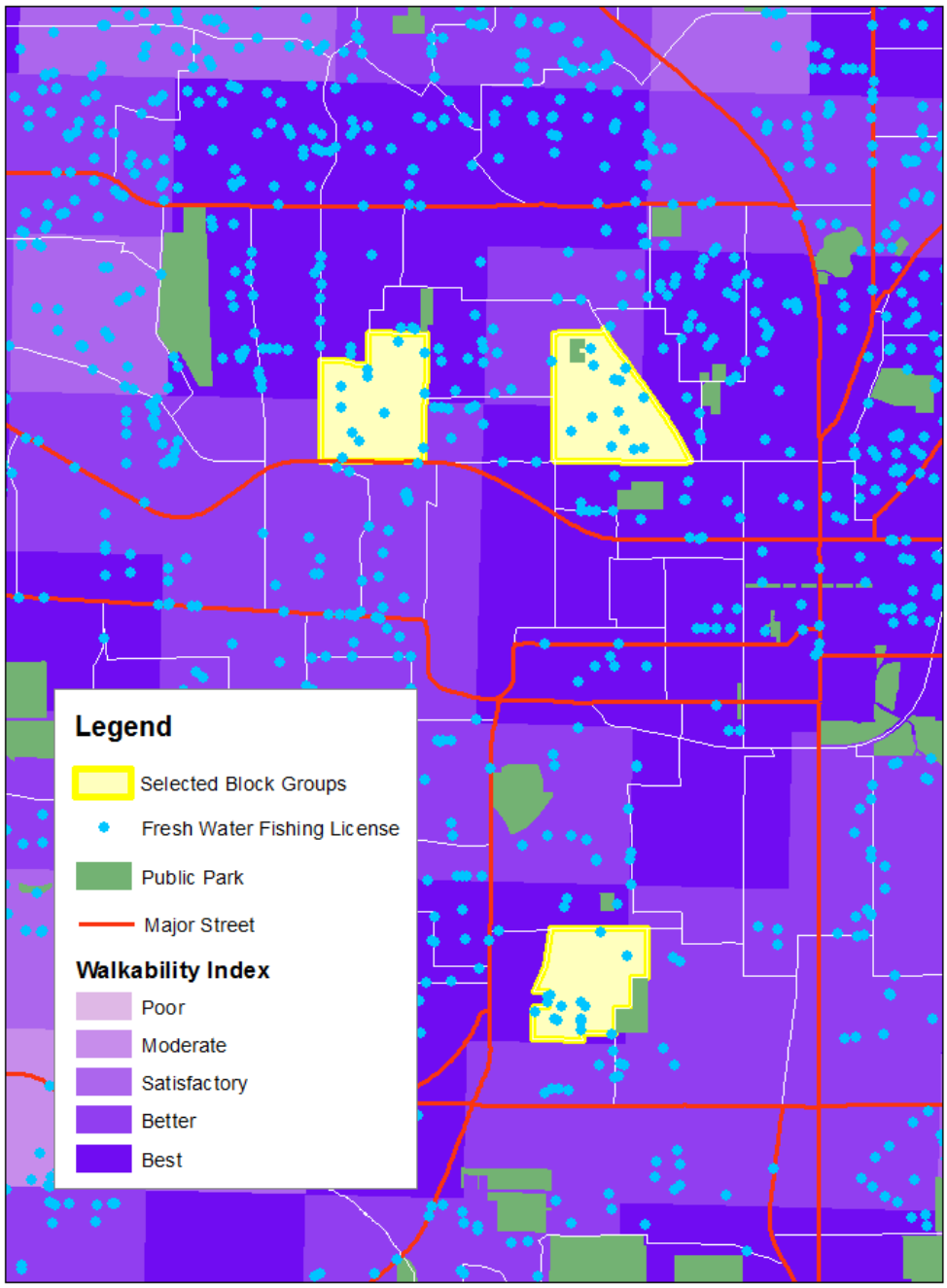

Figure 6. A visualization showing an overlay of all supplemental data.

In interpreting this visualization, proximity to parks and walkability indices could be given a higher priority in the weighted index as research shows the value of these measurements. Fishing licensure could hold a lesser position until future studies quantify the merit of this data.

In conclusion, SES data was used to identify areas of lower education and higher dependence on public assistance. Three types of supplemental non-SES data were used as a means to gage possible levels of physical activity. The preliminary results of this study show that the disadvantaged areas have potential for adequate levels of activity. This conclusion is a general statement about the ability for exercise and is not an assessment at the individual level. This study could be improved with the inclusion of other data, particularly health data such as diabetes or chronic diseases. Crime data could be paired with walkability scores to give a more complete perspective on outdoor safety. The types of supplemental data used here show that the multivariate index is flexible and can be adapted for use in different scenarios.

Discussion

Neighborhoods themselves are often predefined and imprecisely measured. Census tracts and zip codes are often used as units of measure when in reality these artificial boundaries have nothing to do with the actual neighborhood. A study of neighborhood deprivation showed significantly different results when neighborhoods were custom-defined using walking distances rather than by pre-defined census block groups (Gale, 2011).

Individual health is an outcome of many factors. There is a correlation between individual health and the neighborhood of residence, yet we don't fully understand how these factors interact. Many studies use socioeconomic because the data is easy to collect from the census and can be applied consistently to every area of the country. There is no conclusive evidence directly connecting SES and individual health and it is imperative that we consider factors other than the SES in determining neighborhood health. Some of the data mentioned in this review are easy to obtain while other data could be harder to collect and more expensive. Some factors mentioned here have been verified at the individual level and others have not.

Conclusion

When assessing the health of a neighborhood we need to consider more factors than the SES. The SES can be considered a starting point for gaining insight into neighborhoods but can be supplemented with information collected from other sources. Answers to complex questions usually arise from the multi-disciplinary fields. Concerning neighborhood health, communications among health researchers, communities, urban planners, and policy experts are key (Diez-Roux, 2007). This literature review is a starting point for identifying neighborhood factors contributing to the health quality of a neighborhood. Further study is needed to evaluate the importance of these neighborhood factors. The use of GIS and spatial analysis would allow researchers to build more in-depth associations between an individual's environment and factors affecting health. GIS is a proven visualization and analysis tool for public health solutions. GIS was first used for city planning, demography, and epidemiology, and it can now be expanded in helping assist researchers through areas of environmental and public health. Using a weighted multi-attribute index has the the potential to further target areas of specific concern. Assessing the health of neighborhoods can help professionals' better target educational programs and allocation of resources that could improve health care and reduce costs.

GIS technology can be used to visualize and analyze the factors mentioned above. The neighborhood characteristics to be analyzed can be independently selected according to the

health issue being studied. For example, in areas of high asthma, examining trees with high pollen output should be a consideration, but this factor could be excluded regarding most other health issues. The factors mentioned here could be used to create a multi-attribute weighted index. According to Marilyn Winkleby at the Stanford prevention Research Center, "The use of GIS technology allows researchers to look at the density and proximity of goods, services, and community resources such as parks, youth clubs, fast food outlets, convenience stores, and other factors that might enhance or hinder health, in relationship to where people live and work… GIS provides the technology to spatially display, synthesize, and analyze data—it creates a dynamic visual understanding of people, places, and health" (2005). Using the GIS approach to define and assess neighborhoods and health would allow for future research to directly link multiple factors affecting health promotion within neighborhoods and the individual that are not considered within SES.

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